CRASH RISK PERCEPTION OF SLEEPY DRIVING AND ITS COMPARISONS WITH DRINK DRIVING AND SPEEDING: WHICH BEHAVIOR IS PERCEIVED AS THE RISKIEST?

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ABSTRACT

Objective: Driver sleepiness is a major crash risk factor, but may be under-recognized as a risky driving behavior. Sleepy driving is usually rated as less of a road safety issue than more well-known risky driving behaviors, such as drink driving and speeding. The objective of this study was to compare perception of crash risk of sleepy driving, drink driving, and speeding.

Methods: In total, 300 Australian drivers completed a questionnaire that assessed crash risk perceptions for sleepy driving, drink driving, and speeding. Additionally, the participants perception of crash risk was assessed for five different contextual scenarios that included different levels of sleepiness (low, high), driving duration (short, long), and time of day/circadian influences (afternoon, night-time) of driving.

Results: The analysis confirmed that sleepy driving was considered a risky driving behavior, but not as risky as high levels of speeding ($p < .05$). Yet, the risk of crashing at 4 am was considered as equally risky as low levels of speeding (10 km over the limit). The comparisons of the contextual scenarios revealed driving scenarios that would arguably be perceived as quite risky due to time of day/circadian influences were not reported as high risk.

Conclusions: The results suggest a lack of awareness or appreciation of circadian rhythm functioning, particularly the descending phase of circadian rhythm that promotes increased sleepiness in the afternoon and during the early hours of the morning. Yet, the results suggested an appreciation of the danger associated with long distance driving and driver sleepiness. Further efforts are required to improve the community's awareness of the impairing effects from sleepiness and in particular, knowledge regarding the human circadian rhythm and the increased sleep propensity during the circadian nadir.

Key words: crash risk perception, sleepy driving, drink driving, speeding, Australian drivers

INTRODUCTION

Driving while sleepy is a major crash risk factor. Current case-control studies suggest that approximately 20% of all fatal and severe crashes are due to acute sleepiness (Connor et al. 2002; Kecklund et al. 2012). A substantial amount of evidence exists describing the detrimental effects sleepiness can have on perception, motor control, attention, decision making, and executive functioning, which are critical psychological processes for safe driving. The impairment from sleepiness for these psychological processes leads to poorer vehicle control (Philip et al. 2003), impaired attention (Jackson et al. 2012), increased distractibility (Anderson and Horne 2006), reduced visual scanning (Santhi et al. 2007), and impaired hazard perception (Smith et al. 2009). Yet, sleepy driving is usually rated as less of a critical issue for road safety (Pennay 2008; Radun et al. 2015; Vanlaar et al. 2008) and may be under-recognized as a risky driving behavior.

Crash Risk Factors

There are time of day factors and driving situations where levels of sleepiness are greater and can lead to heightened crash likelihood. During the descending phase of the circadian rhythm the incidence rate of sleep-related crashes increase (Connor et al. 2002; Garbarino et al. 2001; Pack et al. 1995). Additional wakefulness or reductions of sleeping time, such as partial, chronic, and total sleep deprivation also results in an increased likelihood of sleep-related crashes (Connor et al. 2002; Garbarino et al. 2001; Stutts et al. 2003). However, the interplay between additional wakefulness (homeostatic factors) and circadian factors can be complicated (Folkard et al. 2006) with a review of the transport and occupational safety literature suggesting that a peak in crash risk occurs slightly after midnight (Williamson et al. 2011). Long durations of driving are also associated with an increased likelihood of having a sleep-related crash (Pennay 2008; Stutts et al. 2003).

Recent data have estimated the relationship between increasing levels of subjective sleepiness and the likelihood of crashing. The odds of having a sleep-related crash rapidly increase in a non-linear, almost exponential curve as subjective sleepiness levels increase (Åkerstedt et al. 2008). Similar, rapid increases in crash risk are also reported for driving while intoxicated from alcohol (Blomberg et al. 2009; Borkenstein et al. 1964) as well as speeding over the posted speed limit (Kloeden et al. 2002) and provide analogous levels of risks. Comparisons between the level of impairment between sleepiness and alcohol intoxication show the decrement of cognitive functioning from modest sleep deprivation (20 hours of wakefulness) approaches levels of impairment of blood alcohol intoxication levels of 0.1% (Williamson et al. 2001). Comparable levels of impairment between sleepiness and alcohol intoxication have also been noted with simulated and closed track driving studies (Arnedt et al. 2000; Powell et al. 2001).

Risk Perception

The dangerousness of sleepy driving has been demonstrated from studies of impairment and crash risk estimates; however, many drivers seemingly continue to ignore this knowledge. Between 59-77% of drivers report they have driven when feeling sleepy (Armstrong et al. 2010; Vanlaar et al. 2008) with many Australian drivers reporting briefly falling asleep after less than one hour of driving (Pennay 2008). More concerning though, are reports that many drivers (73%) would continue to drive even when aware of their increasing levels of sleepiness (Nordbakke and Sagberg 2007). Several studies also suggest that drivers are also cognizant of pre-trip, sleep-related factors that can impact on their sleepiness levels while driving (e.g., Nordbakke and Sagberg 2007; Radun et al. 2015). Considered together, these studies suggest a lack of awareness or appreciation of the dangers of driving whilst sleepy.

A pertinent factor that may influence driving while sleepy is the individual's perception of risk for sleepy driving. Risk perception is suggested to be a causal factor for the performance of health behaviors (Janz and Becker 1984) whereby the more risky a behavior is perceived, the less likely an individual will perform that behavior (Helweg-Larsen and Shepperd 2001). However, scant research has been undertaken comparing crash risk perception of sleepy driving and other risky driving behaviors. Previous work has shown that sleepy driving is not typically perceived as a critical issue for road safety (e.g., Pennay 2008; Vanlaar et al. 2008). A study that has examined the perceived culpability from being involved in a crash either due to sleepiness or alcohol intoxication found participants reported drivers involved in a sleep-related crash were perceived as understandable, however, drivers who crashed after drinking alcohol were culpable for the crash (Williams et al. 2012).

It is also of interest to examine the effect that the context of the driving scenario can have on crash risk perception. Specifically, aspects of the duration of driving, levels of sleepiness, and time of day/circadian effects are likely to influence the perception of risk associated with these contextual factors. It has been suggested that risk perception formed from contextual scenarios have a higher level of specificity than more general or under defined scenarios (Weber 1997). As such, obtaining risk perceptions with scenarios that vary by duration of driving, levels of sleepiness, and different times of the day will be beneficial for understanding drivers' levels of crash risk perception for particular sleepy driving scenarios.

The current study sought to examine driver's perceptions of crash risk of driving when sleepy. The first aim was to compare drivers' absolute crash risk perception of sleepy driving against drink driving and speeding, two well-known risky driving behaviors. The second aim of the study was to examine how perception of crash risk for different contexts of sleepy driving (different levels of sleepiness: low-high, driving duration: short-long, and time of day: different circadian phases) compare to the absolute perceived riskiness of sleepy driving, drink driving and speeding.

METHOD

Participants

Participants were recruited from the membership database of the Royal Automobile Club of Queensland (RACQ). The RACQ is a motoring club and mutual organization, providing roadside assistance, insurance, travel, finance and other services to its members. A total of 1000 randomly selected RACQ members were invited to participate in the study, of which 309 individuals completed the questionnaire. A response rate of 30.90% was obtained.

Measures

Typical demographics were assessed, including: age, sex, education, employment, usual driving situations (e.g., urban, long distances, day or night-time driving), as well as experiences of sleepy driving (e.g., ever felt sleepy while driving, ever had a close call when driving because of sleepiness). A series of purpose designed items were developed to examine the participants' risk perceptions of crashing. Participants were asked to "rate the risk of having a road crash" for each of the driving scenario items on a 10-point Likert scale (1 'no risk' to 10 'extremely high risk'). To assess the participants' *absolute risk perceptions* for sleepy driving, drink driving, and speeding, six items were developed; a low and high level of risk for each risky driver behavior. The wording of the absolute risk perceptions for the low and high sleepiness, low and high drink driving, and low and high speeding were "What is the risk of driving when feeling sleepy?", "What is the risk of driving at 4 o'clock in the morning?"," What is the risk of driving after having 1 or 2 drinks (i.e. BAC under 0.05)?"," What is the risk of driving after having 4 or 5 drinks (i.e. BAC over .05)?"," What is the risk of driving at 10km over the speed limit?", and "What is the risk of driving at 30km over the speed limit?". To assess the participants' *contextual risk perceptions* of crashing, five short vignettes were developed (see Table 1), that were different combinations of level of sleepiness (sleep restricted or not), driving duration (short, long), and time of day of driving (daytime, afternoon, night-time).

Table 1.

The different contextual risk perceptions scenarios and the wording of the vignette.

Scenario	Vignette
(1) Sleep restricted, short distance driving	George has been working a 12-hour shift from 6pm to 6am and is on his way home. George works these shifts for 6 days, then he has 4 days off. Yesterday was his son's birthday so he didn't get his usual 6 hours of sleep before going to work last night. George lives a 15 minute drive from his place or work and is driving straight home.
(2) Sleep restricted, long distance driving	Bruno has had a busy week and has been getting to bed late for the past few nights. He gets to bed at 3am on Tuesday and gets up at 6am to drive to a town one hour away for a series of appointments and then drives home again at 4pm after a full day's work.
(3) Sleep restricted, daytime driving	Jeremy hurt himself at work, and he hasn't had a good night's sleep all week. By the weekend, he is feeling pretty worn out. Because of the pain, he can't 'catch up' on his sleep over the weekend. Jeremy likes to take his car for a 'spin' on Sunday, and will drive on the mountain roads near the city.
(4) Night-time driving	Barry lives and works in the city. This weekend, he wants to take his family to the beach. Barry has been at work all day, and they don't get going until 7pm on Friday night. It has been a long drive, and it is now 11pm. They still have an hour to go.
(5) Afternoon driving	Narelle has to drive to a country town for work. She has driven since 8am this morning, but had an hour's break for lunch. It is now 3pm, the road is very straight, and the scenery is mostly just paddocks and scrub.

Procedure

The study research protocol was approved by the University's Human Research Ethics Committee. The randomly selected participants from the RACQ membership database were mailed a consent form, a paper survey, and a reply paid envelope. Upon completing the questionnaire, the participants returned the completed survey and the signed consent form via a reply paid envelope.

Statistical Analyses

The first analysis compared the absolute crash risk perceptions for the sleepy driving, drink driving, and speeding for the low and high driving scenarios. The second analysis involved comparing the absolute crash risk perception with levels of perceived riskiness for the contextual crash risk perception scenarios. Both analyses employed a repeated measures ANOVA with post hoc pair-wise comparisons, that were Bonferroni adjusted for multiple comparisons to minimize the influence of Type 1 errors. Significance levels were set at $p < .05$ for all statistical tests, unless stated otherwise. If the sphericity assumption was breached the Greenhouse-Geisser correction was reported.

RESULTS

Participants Characteristics

In total, the sample comprised 309 participants (males: 37.38% and females: 62.62%). The mean age of participants was 44.67 years (*SD* = 17.64; range = 17-78). The majority of non-work driving occurred in urban areas mostly during the day (88.36%) or night (2.05%), the remaining participants often drove long distances, either during the day (9.25%) or the night (0.34%). A large majority of participants (77.05%) reported having previously experienced sleepiness while driving with 30.07% reported having a close call on the road because of sleepiness.

Absolute Risk Perception Comparisons

The absolute crash risk perception for low and high risk sleepy driving, drink driving, and speeding can be seen in Figure 1. A repeated measures ANOVA was performed to compare these driving behaviors and can be seen in Table 2. A series of pair-wise comparisons revealed that Low BAC (< .05) driving was perceived as the least riskiest driving behavior and the High speeding behavior of driving 30 km over the limit, perceived as the most riskiest. However, the High sleepiness driving behavior was perceived significantly less risky than the High BAC driving behavior, but as risky as Low speeding; that is driving at 10 km/h over the speed limit. The Low sleepiness driving behavior was perceived as more risky than the High BAC driving behavior, but significantly less risky than the High speeding, driving behavior.

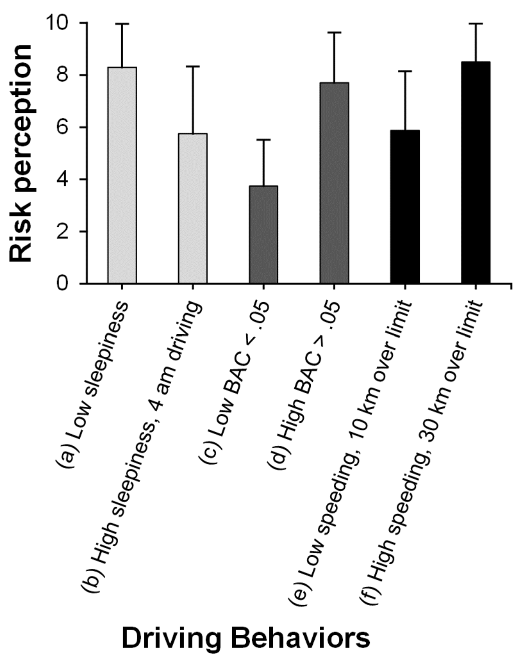

Figure 1. Levels of absolute crash risk perception for the low and high scenarios of driving behaviors of sleepy driving, drink driving, and speeding. Error bars represent one standard deviation.

Table 2. ANOVA results for comparisons of the absolute risk perception of sleepy driving, drink driving, and speed

ANOVA			
F^{a}	p	η_p^2	Pair-wise comparisons[b]
386.14	< .001	.58	c < b, e < d < a < f

[a] Greenhouse-Geisser correction reported; [b] Bonferroni adjusted, $p < .05$.

Contextual Risk Perception Comparisons

The absolute crash risk perception for the driving behaviors of low and high risk scenarios for sleepy driving, drink driving, and speeding were compared to the five contextual sleepy driving scenarios (see Figure 2). The results of the six separate ANOVAs can be seen in Table 3. The alpha level for the post hoc pair-wise comparisons was Bonferroni adjusted.

The Low sleepiness absolute crash risk perception was perceived as risky as the Sleep restricted, long distance driving. In contrast, when High sleepiness, 4a.m. driving absolute crash risk perception was compared to the contextual scenarios it was perceived as the least risky driving scenario. The High BAC driving behavior was considered significantly more risky than the Afternoon driving scenario as well as the Sleep restricted, short distance driving. The High BAC was not rated significantly different from the Sleep restricted, daytime driving or the Night-time driving scenario, and was rated significantly less than the Sleep restricted, long distance driving scenario. The Low speeding driving behavior was rated as risky as Afternoon driving and Sleep restricted, short distance driving. High speeding was perceived more risky than all of the contextual sleepy driving behaviors except for the Sleep restricted, long distance driving.

Regarding the comparisons between contextual scenarios, the scenario of Sleep restricted, long distance driving was rated as the most risky contextual scenario. In contrast, the Sleep restricted, short distance driving and Afternoon driving scenarios were rated the least risky scenarios. Paradoxically the Sleep restricted, short distance driving scenario was rated less risky that the Sleep restricted, daytime driving scenarios.

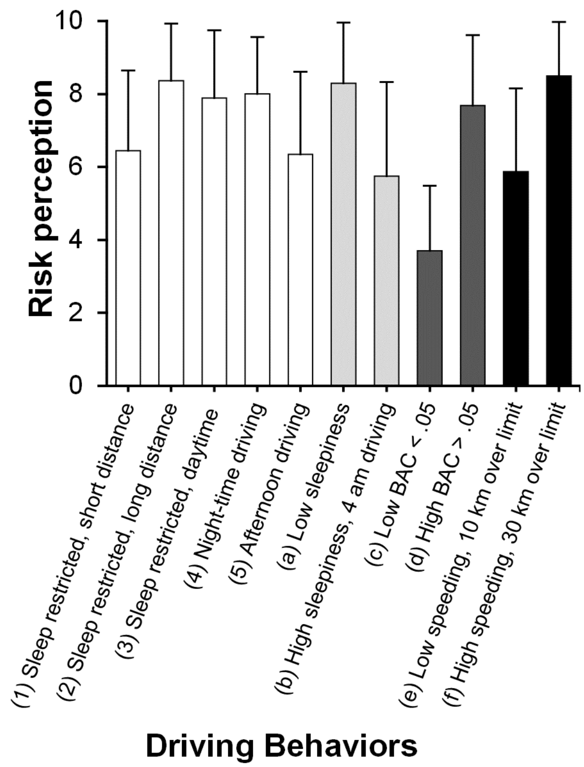

Figure 2. Crash risk perception for the contextual sleepy driving behaviors and absolute risk perception for drink driving and speeding. Error bars represent one standard deviation.

Table 3. ANOVA results for comparisons of contextual sleepy driving behaviors and the comparison behaviors.

	ANOVA			
Comparison behaviors	F^a	p	η_p^2	Pair-wise comparisons[b]
(a) Low Sleepiness	106.99	< .001	.27	5,1 < 3, 4 < a, 2
(b) High Sleepiness, 4a.m. driving	112.16	< .001	.29	b < 5,1 < 3, 4 < 2
(c) Low BAC (< .05)	331.46	< .001	.54	c < 5, 1 < 3, 4< 2
(d) High BAC (> .05)	83.07	< .001	.23	5,1 < d, 3, 4 < 2
(e) Low Speeding (10km over limit)	119.09	< .001	.30	e, 5, 1 < 3, 4 < 2
(f) High Speeding (30km over limit)	119.88	< .001	.30	5, 1 < 3, 4 < 2, f

[a] Greenhouse-Geisser correction reported; [b] Bonferroni adjusted, $p < .05$.

DISCUSSION

The current study sought to examine drivers' risk crash perception of driving when sleepy and compare it to crash risk perceptions for drink driving and speeding. The obtained results suggest that while sleepy driving was perceived as a risky driving behavior, the High sleepiness scenario was rated less risky than many of the other high risk driving behaviors. The second aim of this study was to examine how perceptions of risk of crashing for different contexts of sleepy driving compare to the absolute perceived riskiness of sleepy driving, drink driving and speeding. The data suggested that the contextual scenarios were rated differentially to the absolute scenarios with the differences seemingly dependent on the levels of sleepiness, and the time of day. The implications of these outcomes are discussed below.

It is likely that the participants' appreciation of the influential effects from the descending phase of the circadian rhythm was erroneous. The High sleepiness, 4a.m. driving scenario was perceived less risky than the High BAC driving scenario and the low sleepiness driving scenario. Laboratory based studies show the performance decrement associated with modest sleep deprivation (20 hours of wakefulness) approaches levels of impairment of blood alcohol intoxication levels of 0.1% (Williamson et al. 2001). Additionally, increases in crash frequency occur during night-time driving with the highest incidence rates occurring during the circadian nadir period, which is typically between 02:00-06:00 (Connor et al. 2002; Pack et al. 1995). The increase of sleep propensity that occurs with the descending phase of the circadian rhythm should have resulted in higher perception of risk of crashing being attributed to the High sleepiness, 4a.m. driving scenario. Previous work suggests that knowledge about sleep and in particular, circadian rhythms, are quite limited with community members (Gallasch and Gradisar 2007). The current results seemingly attest to this limited knowledge of sleep and circadian rhythm.

The lack of understanding of the human circadian rhythm also appeared to influence the perceived riskiness of crashing with the contextual driving scenario. The two low sleepiness contextual scenarios were designed such that there was a scenario involving afternoon and night-time driving corresponding to an increase in risk with the change from the ascending to the descending circadian phase. However, the data reveal that these two contextual scenarios were not perceived this way – the afternoon driving scenario was perceived the least risky along with the Sleep restricted, shirt distance driving scenario. An alternate explanation, could be that participants underestimate the detrimental effect chronic sleep restriction (i.e., Sleep restricted, short distance driving scenario) can have on road safety. However, it is also likely that the short distance driving aspect of this scenario might have influenced participants' perception of crash risk, as the Sleep restricted, long distance driving scenario was rated as the most riskiest of all the context driving scenarios.

Limited knowledge and awareness of the dangers of sleepy driving would suggest that drivers are likely to perform it more often. Previous work suggests that drivers that have experienced on-road incidents from sleepy driving typically have higher risk perception that reflect these on-road experiences (Lucidi et al. 2006). Moreover, individuals that have experienced and on-road sleepy driving incident are more likely to utilize more effective sleepiness countermeasures such as napping and consuming caffeine (Anund et al. 2008). In contrast, individuals who drive while sleepy without any adverse outcomes occurring are likely to lower their perception of risk of crashing for sleepy driving, as the relationship between risk perception and risk behavior are bi-directional (e.g., Klein 1997). Support for this notion can be found from studies that reveal more positive attitudes towards sleepy driving are associated with greater likelihood of performing that driving behavior (Vanlaar et al. 2008; Watling 2014).

There appears to be an appreciation of the danger of long distance driving coupled with sleepiness. The Sleep restricted, long distance driving was perceived as the riskiest contextual behavior and was rated similarly risky as the High speeding, 30km over limit scenario. Several studies shown long distance driving is a well-known (and well publicized) risk factor for having a sleep-related crash (Pennay 2008; Stutts et al. 2003). While this is a positive result for road safety, the lack of recognition regarding the dangers of short duration driving, coupled with sleep restriction, is of concern. For instance, approximately a third of drivers who have fallen asleep at the wheel report that the trip duration was less than one hour (Pennay 2008). Simulated and on-road studies suggest that dangerous levels of sleepiness can occur within one hour of driving (i.e., 39-43 mins: Åkerstedt et al. 2013; Watling et al. 2015). Moreover, self-report data suggests that sleep-related close calls (non-crashes) can often occur with 15 minutes of driving (Armstrong et al. 2013).

Falling asleep is not the only way sleepiness can affect safe driving. Sleepiness can impair a number of psychological processes that are needed for safe driving (Jackson et al. 2012; Philip et al. 2003) and these impairments are *not restricted* to long distance driving scenarios. While it is acknowledged that sleep-related crashes occur more often during highway driving episodes (e.g., Horne and Reyner 1995), sleep-related crashes also can occur in urban areas where relatively short duration of driving takes place (Armstrong et al. 2008; Pennay 2008). Additionally, given the neurobehavioral impairments that can occur with even limited sleep deprivation and the fact that most crashes are multifactorial in nature, it is highly likely that sleepiness could contribute to crashes assigned to other risky driving behaviors such as speeding, distracted driving, and alcohol-related crashes (Watling et al. 2013). Increasing driver's knowledge and awareness of the ubiquitous and impairing effects from sleepiness is suggested from the current results and would appear to be a priority for road safety authorities.

The impact of previous efforts to increase drivers' knowledge and awareness of the effects of sleepiness via educational campaigns are equivocal (Fletcher et al. 2005). As such, it is arguable that preventative school based sleep health programs are warranted. Knowledge regarding sleep health and circadian rhythms as well as the consequences of poor sleep health could be included in school curricula (e.g., the subject of biology). An increasing body of literature reveals sleep health programs have been shown to be efficacious with improving knowledge of sleep and circadian factors, but more importantly improving the duration and consistency of sleeping times of children (e.g., Blunden et al. 2012; Cortesi et al. 2004). Additionally, the developmental importance of adolescents sleep health has been firmly promoted by many sleep health practitioners (Carskadon 2010; Matricciani et al. 2012). While longitudinal studies are needed to confirm whether the benefits from school based sleep health programs persist into adulthood, the growing economic cost and distress associated with adult sleep disorders is becoming more apparent (Sleep Health Foundation 2011), let alone the economic cost and trauma associated with sleep-related crashes.

The results from this study need to be interpreted in light of the limitations of the study. First and foremost, the data was obtained via self-report in relation to several hypothetical scenarios. While the current study attempted to provide a context for some of the sleepy driving scenarios to facilitate more specific perceptions of risk (e.g., Weber 1997), the scenarios were still hypothetical. As such, the issue of generalizing self-reported data to actual on-road driving scenarios is an issue for risk perception research. Additionally, no objective values of the risks associated with crashing for sleepy driving, drink driving or speeding were utilized in the current study and thus, only subjective crash risk perceptions were examined. Nonetheless, these subjective perceptions are important as they establish what drivers actually perceive the risks of crashing with sleepy driving, drink driving, and speeding and thus, are helpful with educational campaigns to reduce risky driving behaviors. The current study's data was collected at one time point and as risky behavior can affect risk perception (e.g., Klein 1997), longitudinal studies that control for driving exposure and driving incidents could provide valuable data regarding the process by which behaviors and experiences of sleepy driving can affect risk perception. The use of the vignettes in the current study was limited – such that only five vignettes were used and not all combinations of the driving duration (short-long) and the effect of time of day (daytime, night-time), and level of sleepiness (high-low) were examined. Future research, could seek to explore how these factors might impact upon crash risk perception of driving while sleepy. In addition, the distinction between crash risk perception ratings of self/other for sleepy driving could be substantially different as previous research has demonstrated for other risky driving behaviours (e.g., DeJoy 1989; Harré et al. 2005).

In conclusion, the present study sought to compare perception of crash risk of sleepy driving, drink driving, and speeding. The data suggest that sleepy driving is considered a risky driving behavior, but in some contexts not as risky as drink driving or speeding. There were however, some disparities between the level of risk for short duration driving even when highly sleepy and the level of risk during times of greater sleepiness due to circadian factors. As such, further efforts are seemingly needed to improve the community's awareness of the impairing effects from sleepiness and in particular, basic sleep knowledge regarding the human circadian rhythm.

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