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Hazard perception in novice and experienced drivers: The effects of sleepiness

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ABSTRACT

One driver skill that has been found to correlate with crash risk is hazard perception ability. The purpose of this study was to investigate how hazard perception latencies change between high and low sleepiness for a high risk group (novice drivers) and a lower risk group (experienced drivers). Thirty-two novice drivers (aged 17–24 years) and 30 experienced drivers (aged 28–36) completed a validated video-based hazard perception test, in which participants were asked to anticipate genuine traffic conflicts in footage filmed from the driver's perspective, with separate groups tested at either 10 a.m. (lower sleepiness) or at 3 a.m. (higher sleepiness). We found a significant interaction between sleepiness and experience, indicating that the hazard perception skills of the more experienced drivers were relatively unaffected by mild increases in sleepiness while the inexperienced drivers were significantly slowed. The findings suggest that the disproportionate sleepiness-related accident involvement of young, inexperienced drivers could be partly due to a slowing of their ability to anticipate traffic hazards.

1. Introduction

Sleepiness is regarded as a significant contributor to road crashes (Connor et al., 2001, 2002; Philip and Åkerstedt, 2006), with most estimates suggesting that at least 20% of all vehicle accidents are related to sleepiness (Garbarino et al., 2001; Knipling and Wang, 1994; Lyznicki et al., 1998; Philip, 2001). Further, sleepiness is a good predictor of crash risk (Åkerstedt et al., 2008). Sleepiness-related crashes are also likely to be more severe, and more often fatal, than other types of crash (Åkerstedt, 2000; Bunn et al., 2005). The mechanisms of sleepiness-related crashes can include deficits in attention, vigilance and information processing while drowsy, as well as complete performance failure during frank sleep episodes (Boyle et al., 2007; Durmer and Dinges, 2005; Moller et al., 2006; Van Dongen and Dinges, 2003). Note that self-reported sleepiness while driving corresponds closely to EEG and other objective measures of sleepiness (Kaida et al., 2006), as well as with both simulated and real driving performance (Åkerstedt et al., 2005; Philip et al., 2005).

Young adults (generally defined in this context as teenaged or early/mid-20s) are disproportionately involved in all car crashes (Williams, 2003) but are more likely to be involved in both night-time (Smith et al., 2008) and sleepiness-related crashes than older adults ('older' in this context is generally defined as mid/late-20s and upwards) (Horne and Reyner, 1995; Knipling and Wang, 1994; Lyznicki et al., 1998; Maycock, 1996). We have previously reported that young drivers drive more frequently at times that they felt themselves to be sleepy (Smith et al., 2005) and a number of social and demographic factors are implicated in this increased prevalence.

Another type of factor that differentiates younger novice drivers from more experienced older drivers is driving skill (Crundall et al., 2002; Underwood et al., 2002). In particular, one driving skill, hazard perception, has been associated both with novice/experienced differences (Horswill et al., 2008; McKenna and Crick, 1991; Milech et al., 1989; Wallis and Horswill, 2007) and crash risk (Horswill and McKenna, 2004; Quimby et al., 1986). Hazard perception requires scanning of the road environment, fixation on appropriate stimuli (Mayhew and Simpson, 1995), and a 'holistic' interpretation of the salience of hazards (Milech et al., 1989). Hazard perception is therefore a multi-component cognitive skill that can improve with experience (Deery, 1999). Of all the identified components of driving skill, only hazard perception is reliably related to crash risk (see Horswill and McKenna, 2004, for a review). A number of jurisdictions now mandate a hazard perception test as part of licensing for novice drivers (e.g. four Australian states and the U.K.). Simulator-based assessment of the impact of sleepiness on driving typically focus on parameters such as speed, lateral position, line crossing or steering wheel angle. The impact of sleepiness on hazard perception skill is not known.

Adam et al. (2006) found evidence that younger adults (21–31 years) were less resistant to the effects of sleep deprivation than

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were older adults (61–70 years); however, the mechanisms of this resilience are unknown. There is a natural confound between age and driving experience, such that older drivers are typically more experienced than younger drivers, and matching samples on either factor is fraught (Groeger, 2006). One possible mechanism is that older drivers are more experienced and more skilled in dealing with the effects of sleepiness. If this is the case then we might expect the driving performance of experienced drivers to be less affected by sleepiness than less experienced drivers. In the present project, our aim was to determine whether novice drivers' performance on a video-based hazard perception test was more affected by sleepiness compared with a group of more experienced drivers.

2. Method

2.1. Participants

Thirty-two novice drivers (mean age 19.88 years, SD = 1.94, range 17–24, mean driving experience 1.65 years, SD = 0.80) with up to 3 years post-test driving experience and 30 experienced drivers (mean age 31.78 years, SD = 2.35, range 28–36, mean driving experience 14.41 years, SD = 2.65) with a minimum of 10 years post-test driving experience were recruited via advertisements from within a University population. There were 33 females and 27 males overall (with 2 participants not reporting gender) and no significant difference in gender ratio between the two groups. All participants completed the Epworth Sleepiness Scale (Johns, 1991) and the Pittsburgh Sleep Quality Index (Buysse et al., 1989), and there was no evidence for the presence of any sleep disorders associated with excessive daytime sleepiness. All participants completed a sleep diary for one week prior to testing. Habitual sleep times for all participants were before 12 midnight. There were no significant differences between the novice and experienced drivers in hours sleep per night (novices: $M = 7.65$ h, SD = 1.04; experienced: $M = 7.45$ h, SD = 1.08; $t(58) = .73$, $p = .466$), Epworth Sleepiness Scale score (novices: $M = 8.33$, SD = 2.97; experienced: $M = 7.53$, SD = 3.71; $t(58) = .92$, $p = .36$), or Pittsburgh Sleep Quality Index composite score (novices: $M = 5.33$, SD = 1.99; experienced: $M = 4.27$, SD = 2.74; $t(58) = 1.73$, $p = .090$). The study was approved by the Human Research Ethics Committee of The University of Queensland and participants were paid 80 AUD.

2.2. Design

The study was run as an independent samples design with two factors. The first factor was group (with two levels: novice or experienced), and the second factor was time of testing (with two levels: 10 a.m. and 3 a.m.).

2.3. Materials

2.3.1. Hazard perception test development and validation

We developed a new hazard perception test for this study, based on a method developed by McGowan and Banbury (2004). In previous hazard perception tests, participants typically press a response button or move a lever to indicate the presence of a hazard (Horswill and McKenna, 2004). One weakness of this approach is that there may be more than one potential hazard on screen at any one time, and the response can therefore be ambiguous. In McGowan and Banbury's measure, participants were asked to click on the hazard using a computer mouse. That is, participants had to identify the location, as well as the timing, of each hazard, in an attempt to reduce error variance.

The validity of the test was assessed using the approach of McKenna and Crick (1991), in which it was determined whether the test can differentiate between high crash risk drivers (novices) and lower crash risk drivers (experienced drivers). This is not a trivial step: many previous hazard perception tests have failed to yield differences in response latency between novices and experienced drivers (Crundall et al., 2003; Sagberg and Bjornskau, 2006).

Thirty novice (up to 3 years post-license experience) and 27 experienced drivers (at least 10 years post-license experience) were recruited via the School of Psychology Participant Pool or via acquaintances of the experimenters. The novices were, on average, 19.13 years of age (SD = 3.20) and had 1.22 years (SD = .45) post-test experience. They drove 13,425 km per year (SD = 26,825). The experienced group had a mean age of 48.15 years (SD = 9.02) and had 29.63 years (SD = 8.20) post-test experience. They drove 15,657 km per year (SD = 12,917). Twenty-eight participants were female and 29 were male (the gender difference between the groups was not significant).

The video stimuli for the hazard perception test were created by filming genuine traffic scenes from the perspective of the driver (a car, with a forward-facing camera, was driven in normal traffic in daylight). Any potential traffic conflicts (situations that might result in the camera car having to brake or steer to avoid a collision) that occurred were extracted for use in the test. These were edited into a 20 min video (note that the individual clips making up the video could have one conflict, multiple conflicts, or no conflicts). Examples of potential traffic conflicts included pedestrians stepping out into the road ahead, cars in front braking due to a blockage further ahead, and vehicles pulling out of side streets. Response latencies to potential traffic conflicts were measured using custom-developed software that recorded the location and timing of mouse clicks, and determined whether these responses were to the potential traffic conflicts. Participants' earliest responses to each potential traffic conflict was measured and converted into a reaction time. The overall hazard perception score was the mean response latency across all potential traffic conflicts. If a participant missed a potential traffic conflict, the mean reaction time for that event was substituted (this strategy was chosen as it favoured the null hypothesis though note that alternative strategies yielded the same pattern of results).

Participants in the initial validation study completed the hazard perception test in small groups in a computer laboratory, viewing the stimuli on 15 in. CRT monitors. They were instructed to use the computer mouse to "click on the road user(s) that you believe may be involved in a future traffic conflict with your vehicle", where a traffic conflict was defined as "situations in which a collision or near miss between you and another road user might occur, unless you took some type of evasive action (braking or steering)".

Cronbach's Alpha for the test was .90, indicating good reliability. The novice drivers were significantly slower (M = 3.40 s, SD = 0.55) to respond to potential traffic conflicts than the experienced drivers (M = 3.03 s, SD = 0.56), $t(55) = 2.53$, $p = .014$.

To give the option of following up with a repeated measures design (which, in the event, turned out to be problematic and was dropped – see Section 2.4 for further details), two alternative forms of the hazard perception test were generated; the test was split into two halves and new footage was added to each half to make each version to approximately the same length (20 min). The first version had 46 potential traffic conflicts and the second version had 43. The second test was standardized to have the same mean and standard deviation as the first test. The alternate forms reliability of the two versions of the test was tested to ensure they were equivalent. Twenty-two participants (16 females and 5 males, with 1 participant who did not report their gender), who had a mean age of 22.36 years (SD = 3.43), completed both versions of the hazard perception test in a counterbalanced order. The correlation between the two versions was significant ($r = .83$, $n = 22$, $p < .001$) indicating that the alternate forms were equivalent.