



Impairment of simulated motorcycle riding performance under low dose alcohol

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ABSTRACT

Crash statistics that include the blood alcohol concentration (BAC) of vehicle operators reveal that crash involved motorcyclists are over represented at low BACs (e.g., $\leq 0.05\%$). This riding simulator study compared riding performance and hazard response under three low dose alcohol conditions (sober, 0.02% BAC, 0.05% BAC). Forty participants (20 novice, 20 experienced) completed simulated rides in urban and rural scenarios while responding to a safety-critical peripheral detection task (PDT). Results showed a significant increase in the standard deviation of lateral position in the urban scenario and PDT reaction time in the rural scenario under 0.05% BAC compared with zero alcohol. Participants were most likely to collide with an unexpected pedestrian in the urban scenario at 0.02% BAC, with novice participants at a greater relative risk than experienced riders. Novices chose to ride faster than experienced participants in the rural scenario regardless of BAC. Not all results were significant, emphasising the complex situation of the effects of low dose BAC on riding performance, which needs further research. The results of this simulator study provide some support for a legal BAC for motorcyclists below 0.05%.

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1. Introduction

It is widely recognised that limiting the legal blood alcohol concentration (BAC) for motor vehicle operators improves road safety by reducing crash risk. Although legal BAC limits differ from country to country, motorcycle riders are typically subject to the same limit as car drivers. Of 114 countries surveyed in a World Health Organisation report, almost 40% of countries had a BAC limit of 0.05%, while 25% of countries had a BAC limit of greater than 0.06% (WHO, 2004). It is important to investigate whether generic vehicle operation BAC limits are appropriate for motorcyclists, as motorcyclists are involved in crashes more often at lower BAC than car drivers (Sun et al., 1998). Further, the odds of being in a collision when a rider is under the influence of alcohol is 2.7 times greater than when sober (ACEM, 2009). While post hoc analysis of vehicle operator BAC from road collision data provides valuable information regarding the characteristics of riders who have been involved in crashes, the small numbers of actual cases of riders with positive BAC in such studies makes it difficult to draw firm conclusions. For instance, in Sun et al.'s (1998) study over a one-year period only 13 injured motorcycle riders had a positive BAC compared with 411 car drivers. Although frequency may be low, the consequences are high due to the high vulnerability of the rider compared with the driver; riders have higher injury rates for lower BAC (Sun

et al., 1998; Huang and Lai, 2011; Jama et al., 2011) and alcohol impairment results in more fatal crashes (Siskind et al., 2011).

Two key studies have investigated the effect of low dose BAC on motorcycle riding. The first utilised riding on a test track (Creaser et al., 2009). Experienced riders completed riding tasks under zero alcohol, 0.02%, 0.05% and 0.08% BAC in a repeated measures design. Across almost all tasks, a BAC of 0.08% resulted in greater riding impairment compared with the other conditions. In particular, participants were significantly impaired at performing an offset weave task with a BAC of 0.08%. Additionally when riding a curved circuit, participants had significantly greater standard deviation of speed, and greater occurrence of lane departures when intoxicated, compared with sober. These findings suggest that riding on rural roads, which involves curve navigation, may be more difficult for intoxicated than sober riders. Riding on straight urban roads may also be affected by positive BAC as Creaser et al. (2009) found a significant main effect of BAC on travel speed in a straight line, reaction time in a hazard perception exercise and maximum deceleration during an emergency stop. The variety of vehicle handling skills impaired includes those likely to be required on both rural and urban riding situations. The authors suggest that the effects of BAC are likely to be exacerbated in novice riders. Using a test track study is invaluable for investigating the effects of alcohol on real vehicle handling skills; however, it does not allow for safe investigation of a range of typical road scenarios. On the other hand, simulation provides opportunity for investigating rider performance under relatively realistic road conditions that do not put the rider's or other road users' safety at risk.

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Using a motorcycle riding simulator to examine riding skills under different levels of BAC in experienced riders, Colburn et al. (1993) found increasing BACs of up to 0.1% to be associated with increased riding errors, particularly road departures. These impairments provided strong evidence against a BAC limit of 0.1%. However, when considering a BAC limit of 0.05%, interpretation of the data becomes more difficult. The lower levels of BAC were not well controlled, as participants drank fixed volumes of alcohol rather than having it tailored to their body size, resulting in varying BAC. Nevertheless, results point to a need for further research on low-dose (i.e., <0.05% BAC) alcohol and riding.

Previous motorcycle riding studies have not all considered the effect of BAC on the higher order cognitive skills that are critical for rider safety, such as hazard perception. Arousal and attention are particularly impaired by alcohol consumption (Roehrs et al., 1992) and these skills are vital for successful hazard perception. Findings show that drivers' hazard perception (as measured by a secondary reaction time task) in a driving simulator is significantly impaired at low BAC (Lenné et al., 1999; Leung and Starmer, 2005). Motorcyclists appear to have better hazard perception than car drivers when sober (Shahar et al., 2010; Hosking et al., 2010) so it is possible that hazard perception in riders may not be as impaired by alcohol as it is in car drivers.

The effect of alcohol on hazard perception in drivers is related to changes in visual scanning. Sober drivers demonstrate a wide visual scanning pattern, which means that they can maintain attention on the forward roadway and on-coming traffic as it passes. However, with a BAC of 0.08%, visual scanning range becomes narrower, which reduces hazard perception (Leung et al., 2003). Additionally, low dose alcohol has been linked to increased fixation duration. Using a road safety paradigm, Moser et al. (1998) reported that participants under 0.05% BAC demonstrated significantly longer gaze fixations viewing footage of traffic than when sober. Similar results have been reported using a simple scanning task with a BAC of 0.08% (do Canto-Pereira et al., 2007). This research suggests that increasing BAC in motorcycle riders may result in a tendency to fixate gaze on locations in the visual scene that are less meaningful for riding; for example, fixating on the speedometer at the expense of the forward road scene.

Motorcycle riders' visual scanning patterns change with increasing riding experience. For example, novice riders demonstrate narrower visual scanning patterns compared to experienced riders (Hosking et al., 2010). It is possible that experienced riders have a more flexible search pattern than novice riders, which may put them at an advantage when under the influence of alcohol. Although there is limited research on this issue, experience level would be predicted to interact with BAC so that novice motorcyclists' visual scanning behaviour would be impaired by alcohol to a greater extent than the scanning behaviour of more experienced riders.

In Australia, it is illegal to drive with a BAC of 0.05% or greater for private car and motorcycle licence holders. During the first three years of licensure motorcyclists are limited to zero or lower than 0.049% BAC, varying between states. The stricter requirement for BAC in the first years of driving or riding reflects a concern that alcohol has a greater impact on newly acquired skills than established ones. Graduated licensing schemes allow drivers and riders to gain experience under conditions of low risk whilst skills are still developing. In the Australian state of Victoria, a zero BAC restriction for motorcyclists over the age of 21 who also have a full car driver's licence applies only for the first 12 months post-licensure (VicRoads, 2010). Potentially, this regulation places novice riders with car driving experience (who comprise the majority of all novice motorcyclists in Australia) at greater risk than novice riders without car driving experience.

Uncertainties remain about the effects of low BAC on motorcycle riders with varying levels of experience. The present study used a riding simulator to investigate the effects of low-dose alcohol on vehicle handling and hazard perception. Based on previous findings, it was hypothesised that increasing low (<0.05%) BACs would impair riding performance, hazard perception, and visual scanning patterns in a dose dependent manner for both novice and experienced riders. Secondly, it was hypothesised that the effects of low-dose alcohol would be more significant for novice, in comparison to experienced, riders.

2. Method

2.1. Design

A 3 × 2 mixed design was utilised with alcohol dose ('Dose') as the within-subjects factor (0, 0.02% BAC and 0.05% BAC) and riding experience ('Experience') as the between-subjects factor (experienced, novice). Order of alcohol dose administration was counterbalanced across participants. The research was approved by the Monash University Human Research Ethics Committee.

2.2. Participants

Participants were twenty experienced riders (two female) aged 23–54 years (mean = 37.1 years, SD = 9.9) with an average of 14.15 years (SD 10.3 years) riding experience, and twenty novice riders (two female) aged 18–53 years (mean = 27.2 years, SD = 10.8) who were learners or within the first two years of passing their motorcycle licence test. One additional experienced participant completed a practice ride but withdrew from the study due to simulator sickness; data from this participant are not included in this paper.

All participants were required to hold a driver's licence to ensure that all were experienced road users and to be regular consumers of alcohol reporting 2–10 standard drinks per week. Experienced participants were classified as riding regularly over the past five years covering at least 5000 km total. Participants were recruited from Monash University and the local community via online and newspaper advertisements and were compensated \$40 per session for their time.

2.3. Equipment

2.3.1. Riding simulator

The MUARC advanced driving simulator was reconfigured as a motorcycle riding simulator for the purposes of the research program. The interactive riding simulator uses a real Honda NSR 150 motorcycle. Participants were able to realistically control the throttle, hand and foot brakes, and steering. The simulated scenario was displayed on a curved projection screen providing a 180° horizontal and 40° vertical field-of-view with an additional screen for the rearward view (see Fig. 1). The motorcycle was fixed in a static, vertical position to allow participants to have both feet on the foot pegs, emulating a real riding position; however, the simulator did not move dynamically in terms of pitch, roll, or heading. A digital speedometer was presented on the instrument panel of the motorcycle, to allow participants to monitor their speed. Lateral position, speed, throttle and brake use were recorded. Speed was recorded from when participants reached 500 m from the start point (to exclude acceleration up to speed), until the end of the ride.

2.3.2. Scenarios

Participants were presented with urban and rural road scenarios under each alcohol condition. The order of presentation was counterbalanced across participants, and remained consistent across the alcohol conditions. For both scenarios, oncoming traffic

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