Hazard perception and responding by experienced and inexperienced motorcyclists

Liu, C. C.[1], Hosking, S. G.[2], Bayly, M.[1], Mulvihill, C.[1], & Lenné, M. G.[1]

[1]Monash University Accident Research Centre (MUARC)
[2] Defence Science & Technology Organisation (DSTO)
email: charles.liu@muarc.monash.edu.au

Abstract

The overall aim of this project was to identify the fundamental skills necessary for hazard perception in motorcycle riding. In particular, we aimed to determine the differences between experienced and inexperienced motorcycle riders in their ability to perceive and respond to hazards. These aims were addressed using a focus group discussion and four experiments. Hazard perception tasks were tested on various groups including: experienced drivers with no riding experience, experienced riders who were also experienced drivers, inexperienced riders who varied in driving experience, and novice riders who varied in driving experience. This paper provides an overview of the major findings of the project. We also discuss the difficulties associated with research using motorcycle simulators.

Keywords

Motorcycle safety; hazard detection; riding experience; simulators

Introduction

International road safety data indicate that the rate of death or injury for motorcycle riders is far greater than that for other vehicle users. In 2004, U.S. data showed that motorcycle riders were 34 times as likely as passenger car occupants to suffer a fatal injury, and 8 times as likely to suffer a minor injury [1]. Similar estimates have been reported in Australia [2].

One approach to addressing this problem is through testing and training to ensure that riders have the necessary skills to avoid accidents. Traditionally, rider training programs have focused on vehicle control skills [3]. Overall, it remains unclear whether the training of vehicle control skills can reduce the incidence of motorcycle crashes.

To date, rider training programs have generally neglected the important skill of hazard perception: the ability to identify potentially dangerous traffic situations [4]. It has been suggested that training hazard perception skills in car drivers can reliably transfer to real driving situations [5]. It is possible that hazard perception training may also improve hazard perception in motorcycle riders, although there has been little research on this topic to date.

The present project addressed two distinct questions. First, what are the critical hazards that motorcyclists (compared to car drivers) need to detect and respond to? Second, what are the differences between experienced and inexperienced motorcycle riders in their ability to perceive and respond to hazards? These two questions were addressed using various experimental methods and a focus group.

Method

Experiment 1 attempted to validate the Simulator at the Monash University Accident Research Centre as a tool for measuring hazard perception. The participants (see Table 1) travelled through simulated rural and CBD/residential scenarios, with motorcycle riders seated on a motorcycle (Figure 1) and car drivers seated in a car (Figure 2). None of the experienced drivers reported having had any experience riding motorcycles.

Table 1: Experiment 1 demographics.

	Experienced riders	Experience drivers
Licence type		
Motorcycle	Full	None
Driver	Full	Full
Gender (N)		
Male	11	10
Female	4	4
Age (years)		
Range	26 to 51	20 to 56
Mean	39	33
Licence or permit (mths or yrs)		
Motorcycle	16.6 yrs	NA
Drivers'	20.8 yrs	17.3

The MUARC simulator was programmed as an open-loop system, such that any responses from the rider (e.g., steering, accelerating, or braking) did not affect the simulated environment or vehicle behaviour. The time that participants took to respond (by a button-press) to each hazard was recorded. Participants also reported a range of subjective responses (on a 10-point scale) including: the likelihood of a crash, immediacy of threat, and representativeness for each of the hazards that they detected. Participants in all experiments were given the same definition for a hazard: "a feature of the road or environment that has an immediate or potential threat to their personal safety as a rider." Results from this experiment were supplemented by a focus group discussion with a separate group of experienced motorcycle riders (n=8).

Figure 1: Riding simulator set-up for motorcycle rider hazard perception experiment.

Figure 2: Driving simulator set-up for car driver hazard perception experiment.

Experiment 2 compared the response times and eye movements of experienced and inexperienced motorcycle riders in a hazard perception task, which involved a CBD/residential scenario, and a rural scenario. Demographic information about the participants is reported in Table 2. Data from Experiment 2 were collected from riders who were not wearing a helmet. An additional control study (Experiment 3) was performed to examine the effects of wearing a helmet on visual search patterns.

Table 2: Experiment 2 demographics.

	Experienced riders	Inexperienced riders (full drivers	Inexperienced riders (probationary drivers)
Licence type			
Motorcycle	Full	Learner permit	Learner permit
Driver	Full	Full	Probationary
Gender (N)			
Male	13	14	7
Female	1	0	2
Age (years)			
Range	28 to 69	21 to 48	18 to 25
Mean	41	31	20.3
Licence or permit (mths or yrs)			
Motorcycle	14.4 yrs	4 mths	7 mths
Drivers'	22.8 yrs	12.5 yrs	2.3 yrs

In Experiment 4, the focus was on riding behaviour in response to hazardous events, rather than merely detecting or recognising hazardous events. Riders at three levels of experience were tested: experienced, inexperienced, and novice (see Table 3). The effect of driving experience was also assessed by comparing two groups of novice riders: one group with full drivers licences, and the other group with probationary drivers licences. The riders were tested in an interactive, closed loop simulator (the Honda Riding Trainer), which included several realistic motorcycle controls (Figure 3).

Table 3: Experiment 4 demographics.

	Experienced riders (full drivers)	Inexperienced riders (full drivers)	Novice riders (full drivers)	Novice riders (probationary drivers)
Licence type				
Motorcycle	Full	Learner permit	None	None
Driver	Full	Full	Full	Probationary
Gender (N)				
Male	9	12	10	8
Female	3	0	5	2
Age (years)				
Range	31 to 52	20 to 56	22 to 58	19 to 21
Mean	41	33	34	20
Licence or permit (mths or yrs)				
Motorcycle	14 yrs	8 mths	NA	NA
Drivers'	22 yrs	13 yrs	16 yrs	21 mths

Figure 3. Honda Riding Trainer.

Results

Experiment 1

Certain hazards were identified more often by experienced motorcycle riders than by the experienced car drivers. For example, an average of 64% of riders rated the following four events as hazardous: (i) road veering left over a bend, (ii) a railway crossing, (iii) a patch of road-surface repair work, and (iv) a road-works sign. However, none of the car drivers responded to the road-veering hazard, or the patch; while an average of 40% of car drivers responded to the railway crossing hazard and the road-works sign.

Furthermore, the motorcycle riders rated the CBD/residential hazards as a greater threat than did car drivers, but no such differences were found for the rural hazards. A distinction can be made between hazards that involve other road users (road-user-based hazards), and those that involve the road surface (road-surface-based hazards). The motorcycle riders, who were all experienced, detected many of the road-user-based hazards 4 seconds sooner than did the car drivers. (Statistical tests confirmed that this difference was statistically significant.) One possible explanation for this result is that because the consequences of a crash can be more severe for motorcycle riders, they need to be more vigilant of potential collisions.

In general, the road-surface-based hazards were detected more often by motorcycle riders than by car drivers. This result was expected because many of the road-surface-based hazards were more immediate to motorcycle riders; the impact of such hazards on car driving would have been minimal. The road-surface-based hazards that were rated as most hazardous by riders were those that occurred on bends (e.g., roads veering over hills).

Overall, experienced motorcycle riders (compared to experienced car drivers) responded earlier to hazards, and detected a greater number of hazards. Thus, the hazards presented in the simulator can be used to reliably discriminate between experienced motorcycle riders and experienced car drivers. Furthermore, this suggests that there may be scope to improve the hazard perception skills of experienced car drivers when they first learn to ride a motorcycle.

Focus group

Results from Experiment 1 were supplemented by a focus group discussion, where experienced motorcycle riders were invited to discuss the critical hazards that they faced in the real-world. A list of open-ended questions was developed to guide the focus group discussions. The participants were not prompted about the hazards used in Experiment 1. Nonetheless, they independently confirmed that the simulated hazards were representative of the types of hazards that experienced riders identified as critical for motorcycle rider safety. The focus group also indicated that road-surface-based hazards are mostly dangerous when they occur on curved sections of road, which is consistent with the subjective hazard ratings in Experiment 1.

Experiments 2 and 3

In Experiment 2, we predicted that experienced motorcycle riders would respond to hazards faster than, and display different visual search patterns to, inexperienced motorcycle riders. Furthermore, if the hazard perception skills acquired in the driving domain can be transferred to motorcycle riding, then riders who are experienced car drivers would display superior response times and visual search strategies compared to riders who are inexperienced car drivers.

We found that experienced motorcycle riders responded to hazards faster than did inexperienced riders. In rural scenarios, experienced riders were faster than both groups of inexperienced riders by about 3.6 seconds. In CBD/residential scenarios, there were no differences between experienced motorcycle riders and inexperienced riders who were experienced drivers. However, both of these groups responded faster than inexperienced riders who were inexperienced drivers by about 1.7 seconds. (All differences reported here were statistically significant.) Thus, it appears that prior riding and driving experience can both affect hazard perception latencies. These time differences can have a large influence on riders' real-world responses to hazards. A one-second reduction in response times in the rural scenario (at 80 km/h), and a one-second reduction in response times in the CBD/residential scenario (at 60km/h), would correspond to the identification of hazards when they were approximately 22.2 metres and 16.6 meters further away, respectively.

One possible explanation for why the experienced riders were faster to respond to hazards is that they visually fixate on the hazards earlier. However, there were no differences between experienced and inexperienced riders on the amount of time taken to first fixate on a hazard once it was visible. An alternative explanation is that experienced riders recognise that an object is hazardous earlier than do inexperienced riders. After fixating on a hazard, the experienced riders responded 1.6 seconds faster than did the inexperienced riders. Therefore, it appears that one aspect of well-developed hazard perception is the ability to rapidly recognise which objects in the environment are potential threats.

There were no differences in the visual search patterns of the different riding groups on the horizontal plane. On the vertical plane, the experienced riders visually searched an area that was closer to the front of the motorcycle than did the inexperienced riders (i.e. lower on the vertical plane). This visual search pattern appears to be one in which the rider is able to monitor other traffic visible from a far distance, as well as one in which the rider can detect hazards on the road surface that are only visible from closer distances.

Data from Experiment 2 were collected from riders who were not wearing a helmet. An additional control study (Experiment 3) demonstrated that the visual search patterns were not significantly affected by wearing a helmet. Overall, it was concluded that the visual scanning patterns of experienced riders facilitate the early detection and responding to road-user-based and road-surface-based hazards. The results suggest that scanning behaviours which may facilitate visual and attentional processing for the early detection and response to hazards are better developed in experienced riders than in inexperienced riders.

Experiment 4

The earlier experiments suggested that experienced riders produce faster recognition responses to hazards, which may allow more time to take appropriate actions to avoid a crash. Furthermore, experienced riders may have a better understanding (or "mental model") of typical hazardous events [6]. That is, experienced riders can more easily, or at least more rapidly, anticipate hazardous objects, and accurately predict the possible consequences of various actions. This highly developed mental model would allow for superior behavioural responses. Thus, the main prediction in Experiment 4 was that experienced riders should show superior hazard response skills compared to less experienced riders, and that this advantage would also be reflected on vehicle-based measures, such as speed. An additional prediction was that novice riders who were experienced drivers should show superior skills to novice riders who were inexperienced drivers.

Three variables of interest were analysed from the simulator (Honda Riding Trainer): frequency of crashes, grades provided by the simulator, and vehicle speeds. It was found that novice riders who were inexperienced drivers crashed the most frequently, while in the remaining three groups, the proportions of crashes did not vary with experience. Second, experienced and inexperienced riders produced higher grades (based on evaluations given by the simulator program) than did the two groups of novice riders. Finally, experienced riders could achieve a lower speed at one second after hazard onset than inexperienced or novice riders. (A detailed presentation of these results is beyond the scope of this paper, and will be presented elsewhere.)

Experiment 4 showed that both riding and driving experience have effects on motorcycle riding behaviour in response to hazardous events. This experiment extended the earlier experiments in this research program, which found differences in scanning strategies and button-press responses.

Discussion

The overall aim of the present project was to identify the fundamental skills that are required for expert hazard perception in motorcycle riding. The identification of such skills could yield many useful applications, such as the development of a hazard perception training program for novice and inexperienced motorcycle riders. In Experiment 1, a representative set of hazards were identified for future testing or training of motorcycle hazard perception. In Experiment 2, experienced motorcycle riders were 1-3 seconds faster to respond to hazards than were inexperienced motorcycle riders. This difference was due largely to the time required to determine that an object was a hazard after it had been fixated. On the vertical plane, experienced riders exhibited wider scanning patterns than did the inexperienced riders. Although there were no differences in time to first fixate on hazards, the difference in scanning patterns probably contributes to differences in peripheral visual processing which cannot be assessed by eye movement data alone. Experiment 3 confirmed that results from Experiment 2 could be reliably generalized to real-world riding behaviours where helmet use is mandatory. In Experiment 4, experienced motorcycle riders were also better than inexperienced riders at avoiding hazards on an interactive simulator. Previous driving experience also appeared to have a beneficial influence on responses to hazards on a motorcycle simulator.

In the remainder of this discussion, we outline some critical issues relating to the use of simulators in motorcycle research. The Honda simulator differed from the MUARC simulator on three key factors: (1) level of rider interaction, (2) programming of scenarios, and (3) field of view. The pros and cons associated with each of these factors (and the implications for the results) are discussed below. Future experiments in this domain should use a simulator that combines the strengths of both.

Level of rider interaction

In Experiments 1 to 3 (which used the MUARC simulator), the level of rider interaction with the simulator was low. The MUARC simulator was programmed as an open-loop system, such that any responses from the rider (e.g., steering, accelerating, or braking) did not affect the simulated environment or vehicle behaviour. The focus in those experiments was on the visual detection and recognition of the hazard, rather than on the response to the hazard. By contrast, in Experiment 4 (which used the Honda simulator), the level of rider interaction was high. The Honda simulator was programmed as a closed-loop system, such that riders could navigate the scenarios using a wide range of motorcycle controls. The focus on Experiment 4 was on the response to the hazard.

One of the limitations of the open-loop system is that it lacked physical fidelity: In the real-world, riders cannot just sit passively and respond to hazards by a button-press alone. Nonetheless, this system offers greater experimental control over the stimulus presentation and data collection, which are important advantages for research purposes. For example, because the presentation of scenarios was exactly the same for all participants, any differences observed between groups can be more reliably attributed to differences in early hazard detection abilities.

One of the limitations of the closed-loop system is a reduction in experimental control. Because the participants were free to navigate the scenarios in their own way, the presentation of the scenarios was not constant across participants. Furthermore, the response measures in the closed-loop system were more difficult to quantify than those in the open-loop system.

Programming of scenarios

The MUARC simulator allowed for completely programmable (i.e., modifiable) scenarios. This allowed full control over the selection and inclusion of suitable hazardous events. In particular, the selected events met several criteria, in that they: (i) developed into an actual hazard that would eventually be identified by untrained riders, (ii) could be anticipated by both experienced or trained novice riders, (iii) required scanning ahead and/or to the side, and (iv) were presented in clear and uncluttered scenarios so that there could be no doubt as to what participants were responding. These stimuli were initially tested in a pilot experiment, and changes were then made following feedback from participants who were experienced motorcycle riders.

The Honda simulator provided pre-programmed scenarios that could not be modified to suit our research needs. This inflexibility, in part, explains some of the difficulties associated with interpreting the data from Experiment 4. In the context of the criteria stated above, it is clear that many of the hazardous events that were pre-programmed in the Honda simulator were not ideal for research purposes.

Field of view

The scenarios on the Honda simulator were projected onto a standard PC monitor. This relatively small display compresses the simulated objects so that they were much smaller than their actual sizes. In addition, the small field of view available to riders meant that any eye movement data would not correspond to real-world scanning behaviours. Furthermore, the hazardous events could not appear gradually from the periphery.

In contrast, scenarios on the MUARC simulator were projected onto a display screen that subtended a visual angle of 180 degrees horizontally and 40 degrees vertically. This large display offered a realistic simulation of real-world riding experience, in which the sizes of the simulated objects were actual sizes. The large field of view available to riders meant that eye movement data would correspond to real-world scanning behaviours and could be analysed in a meaningful way.

Conclusion

This paper reports an overview of an exhaustive two-year program of research conducted at MUARC addressing hazard perception in motorcyclists, and in particular, is the first study to compare the hazard perception abilities of inexperienced and experienced motorcycle riders. While we have found interesting preliminary results, we believe that considerably more research is needed in this area. Perhaps one of the more important outcomes from this research is the valuable insights gained regarding the requirements for a simulation facility to better support the conduct of motorcycle safety research. While the currently available methodologies have their strengths, one possible avenue for further research might involve experiments using an interactive motorcycle simulator that has a realistic field of view and also allows for a high degree of flexibility in scenario design and performance measurement. Such research may be critical for the development of an effective hazard perception training program for motorcycle riders.

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