HAZARD PERCEPTION AND RESPONDING IN CAR DRIVERS AND MOTORCYCLISTS

Session: Motorcyclists

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Abstract

Poor hazard perception skills have been shown to contribute to novice driver crash involvement. Comparatively little research has examined the relevance of hazard perception and responding in the crashes of novice motorcyclists. Motorcyclists are subject to the same hazards faced by car drivers but are also at risk from situations not hazardous for car drivers, such as gaps in bridge decking wide enough to catch a motorcycle wheel but too narrow to affect a car tyre. The reactions required from riders also need to be different, as motorcycles handle differently to cars. The extent of potential harm associated with any given hazard is commonly greater for motorcyclists, given their comparative lack of protection.

Most novice riders are experienced drivers. Also, many riders who have held a licence for some time have limited riding experience. These issues question the relevance of the results of car driver hazard perception research for novice motorcyclists.

This paper describes these issues using the findings of the first stage of a program of research into hazard perception training for motorcyclists. Based on a literature review and the results of an analysis of Victorian motorcycle crash data, the paper examines differences in the hazard perception and responding skills and requirements of novice riders and drivers. The implications of these findings for riders' training needs and the role and potential utility of a hazard perception test for motorcyclists are then discussed in brief.

The two general approaches to improving the safety of road users are to prevent crashes and to reduce the severity of injury in the event of a crash. Crash prevention is relatively more important for vulnerable road users such as pedestrians, bicyclists and motorcyclists who are not encased in metal structures. For bicyclists and motorcyclists, the ability to perceive and respond to hazards posed by other vehicles and by the road surface is crucially important.

Motorcycle riders are subject to specific hazards in addition to those that they have in common with car drivers. The rider's evaluation of level of risk also needs to take account of the different performance characteristics of a motorcycle compared with a car and the lower levels of injury protection afforded by the motorcycle. Thus, the findings regarding hazard perception in car drivers and the content and delivery of training that has been developed for car drivers may not necessarily be appropriate for motorcycle riders.

This paper is based on the findings of the first stage of a project to investigate hazard perception training for motorcyclists. Based on a literature review and an analysis of Victorian motorcycle crash data, the paper examines differences in the hazard perception and responding skills and requirements of novice riders and drivers. The implications of these findings for riders' training needs and the role and potential utility of a hazard perception test for motorcyclists are then discussed in brief.

DEFINITIONS AND THEORIES

The term "hazard perception" is widely used, both in the scientific literature and by those interested in improving driver and rider safety. However, different people use the term to refer to different concepts and this can lead to misunderstanding and confusion (as noted by Evans and Macdonald, 2002). In addition, terms such as hazard and risk are often used interchangeably and definitions of hazards vary.

For the purposes of this report, the following definition was developed by the authors:

> *"A hazard is any permanent or transitory, stationary or moving object in the road environment that has the potential to increase the risk of a crash. Hazards exclude characteristics of the rider or the vehicle, which are classed as modifying factors."*

This definition focuses on the hazard as an object and separates the concept of a hazard and the concept of the risk that is associated with the hazard.

Modifying factors

Modifying factors are those characteristics of the rider or the motorcycle that modify the level of risk of a hazard. They can be long-term characteristics of the individual such as rider experience and rider skill in executing responses (real or perceived) or more transitory characteristics such as travel speed, type of protective clothing worn and mechanical condition of the motorcycle. Many of the transitory modifying factors may be affected by the longer-term modifying factors (e.g. travel speed may be higher in riders who perceive themselves as more skilled). The same object could be considered as a hazard in some situations but as a modifying factor in other situations (e.g., a wet road).

Hazard perception

Hazard perception was defined by Crick and McKenna (1992) as the ability to identify potentially dangerous traffic situations. Evans and Macdonald (2002) define hazard perception as "the process whereby a road user notices the presence of a hazard" (p.93). This definition fits well with the definition of a hazard that the authors have developed. Figure 1 shows that hazard perception can be considered as one of the stages in responding to the presence of actual or potential hazards.

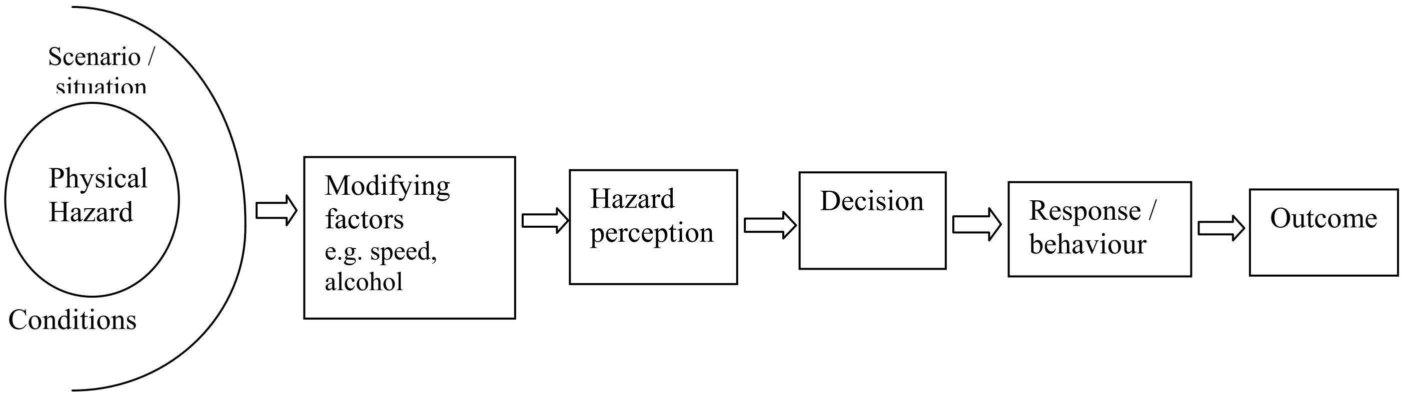

Figure 1. A possible model of the role of hazard perception in the chain of processes linking the existence of physical hazards and outcomes.

An outcome of the hazard perception and responding process might be to change the levels of the modifying variables – the response might be to slow down, which then changes the modifying variable of speed. Changes to the modifying variables might occur over a longer timeframe, and this may be what happens in gaining experience and learning to ride more safely.

Theoretical frameworks

Several different theoretical frameworks have been applied to hazard perception by car drivers including recognition-primed decision making (Klein, 1993), situational awareness theory (Endsley, 1995) and an evolutionary framework (Harrison, 2002). Try in f&H report 161

The recent four component model of responding to risk (Grayson, Maycock, Groeger, Hammond and Field, 2003) may be the most applicable to motorcycling because it includes a response implementation phase, which appears to be more important in motorcycling than in car driving (Haworth et al., 2000). The underlying principle of the model is that "drivers differ in accident liability [similar to crash risk] because they differ at an individual level; that is, they differ in their abilities to detect and recognise potential hazards, and in their abilities to respond appropriately to those hazards" (p.38). The model has four components:

- Hazard Detection – being aware that a hazard may be present
- Threat Appraisal – evaluating whether the hazard is sufficiently important to merit a response
- Action Selection – having to select a response from one's repertoire of skills
- Implementation – performing the necessary actions involved in the response that has been selected

The four-component model focuses on the effects of stable personality traits, rather than states of the individual (e.g. sobriety). It is likely that modifying factors such as alcohol would affect several components of the model, including threat appraisal and implementation (e.g. by lengthening reaction time). The model does not specifically deal with transient modifying factors that influence the potential severity of the outcome such as speed.

DIFFERENCES BETWEEN NOVICE RIDERS AND DRIVERS

It is important to consider the extent to which the findings of research into hazard perception and responding conducted with car drivers are relevant to motorcyclists, given the different vehicle control skills required for safe riding and given the additional or different hazards relevant to motorcycling (see Haworth et al., 2000). Another important issue is the extent to which the findings of research conducted elsewhere are relevant to Victorian motorcyclists, given their age and experience profiles (both in car driving and motorcycle riding).

Much of the research in hazard perception and hazard perception training has focused on young novice car drivers. This group is both young and inexperienced. The research has demonstrated that their hazard perception skills are poorer than older, more experienced drivers. It has also shown that hazard perception training can improve their performance on hazard perception tests to a level similar to older, more experienced drivers. However, many Victorian motorcyclists are not young and many have more car driving experience than motorcycling experience. In 1998, 84% of riders obtaining a motorcycle licence in Victoria held a full car licence. This means that they had at least three years solo driving experience in addition to up to two years driving with a supervisor.

Little is known about the relationship between age and experience and ability in hazard perception and responding for such a group of motorcyclists. It is not known to what extent experience as a car driver is expected to improve hazard perception and responding skills as a motorcycle rider. This is important given that most motorcyclists in Victoria are experienced car drivers.

Age, licensing and experience

For car drivers, there is a reasonably reliable relationship between how long a licence has been held and the level of experience gained (in terms of distance driven). The relationship is not as clear for motorcyclists. Many riders have held a licence for an extended period but have little riding experience. For many who currently hold a licence, their riding experience occurred many years ago. It is possible that the need for improved hazard perception and responding skills is not limited to riders entering the licence process but may apply to many fully licensed riders.

Thus, there is a need to assess for which categories of motorcycle riders – younger, older, novice, experienced, returning – hazard perception and responding needs to be improved and how this could be done.

HAZARDS FOR MOTORCYCLE RIDERS

Motorcyclists are subject to the hazards faced by car drivers but because they are two-wheelers, they are more susceptible to difficulties and hazards created by the design, construction, maintenance and surface condition of roads (ROSPA, 2001). The reactions required from riders also need to be different, as motorcycles handle differently to cars. The extent of potential harm associated with any given hazard is commonly greater for motorcyclists, given their comparative lack of protection.

Armsby, Boyle and Wright (1989) found that car drivers who also rode (or had ridden) motorcycles were able to identify specific features of the road, and specific actions of other road users, as hazards to motorcyclists, while car drivers focused only on hazards arising from the behaviour of other road users.

Road based hazards

Road based hazards can be categorised as permanent characteristics of the road surface (e.g.roughness, being an unsealed or gravel road), temporary characteristics of the road surface (e.g., potholes, surface irregularities), visual obstructions (e.g., stationary vehicles, vegetation), and characteristics of the road alignment (e.g., horizontal and vertical curves).

An early study of motorcycle accidents in Los Angeles, concluded that less than 5% of crashes were caused primarily by roadway defects or adverse weather conditions. However, the road surface was found to have actively contributed to the occurrence of the crash in 15% of inspected sites examined by Haworth, Smith, Brumen and Pronk (1997). A recent survey by the NSW Motorcycle Council showed that 67% of the single vehicle crashes were considered by riders to be associated with loss of traction due to road surface conditions.

Ouellet (1982) concluded that obstruction of the pre-crash line of sight between the motorcycle and the vehicles with which it collides is perhaps the most substantial environmental contribution to crash causation. It was found that one third of motorcycle crashes involve obstruction of the motorcyclist's and/or car driver's view of each other in the moments just prior to the collision.

While road based hazards can, in some cases, cause loss of control of the motorcycle, their role is more often contributory when the motorcycle is performing a complex manoeuvre such as turning or braking.

Hazards associated with the behaviour of other road users

Relatively more is known about the extent of involvement of hazards relating to the behaviour of other road users in motorcycle crashes because these hazards are easier to identify than road based hazards. Allardice's (2002) list of hazardous road configurations includes a number of situations that reflect the hazards associated with the behaviour of other road users:

- Roundabouts and intersections (other vehicles may fail to give way)
- Traffic lights (possible rear-end crashes and red-light runners)
- Motorways (high speeds close to "disinterested, inattentive, impatient, stressed and distracted vehicle drivers")
- Bridges (no escape route from potential head-on collisions)

The hazards associated with the behaviour of other road users can be thought of as arising from failures of hazard perception by other road users. Thus, many of the factors that interfere with hazard perception by car drivers (e.g. distraction associated with mobile phone use) contribute to those car drivers being hazardous to motorcyclists. The extent to which this can and should be addressed by improving the hazard perception and responding skills of motorcycle riders, compared with the corresponding skills of car drivers is a matter for debate.

Studies in the United States, Great Britain, Victoria and New South Wales have found that the other vehicle is at fault in about 60-75% of motorcycle multi-vehicle motorcycle crashes (Hurt, Ouellet & Thom, 1981; de Rome, Stanford and Wood, 2002; Booth, 1989, cited in ROSPA, 2001). A TRL analysis of fatal crashes involving motorcycles that occurred between 1986 and 1995 (Lynam, Broughton, Minton and Tunbridge, 2001) found that 'Failed to give way' and 'poor turn/manoeuvre' were common in crashes for which the non-rider was largely responsible and were associated with failure to observe satisfactorily, careless, thoughtless or reckless behaviour, or failure to judge the rider's path or speed.

HAZARD PERCEPTION AND RESPONDING IN VICTORIAN MOTORCYCLE CRASH DATA

Analyses of Victorian motorcycle crash data were undertaken in an attempt to identify those hazards and situations which pose a crash risk for motorcyclists and to assess the possible capabilities for riders to 'self-monitor' and 'risk compensate' for their skill deficiencies. However, motorcycle crashes reported to the Police provide limited information about the role of hazards and hazard perception and responding. Many crashes involving only the rider, in which road-based hazards may have played a role, are not reported to Police. For those motorcycle crashes that are reported to Police, there is little mention of hazards related to the road surface and hazards related to the behaviour of other road users are not always easy to identify.

The types of crashes in which young and older novices (defined as holders of learner, restricted or probationary licences) and fully licensed riders are involved were compared. It is assumed that the older (over 25) novices also hold full car licences. This provides an indication of the hazards and situations that they encounter. It also provides a general indication of the extent to which their abilities in hazard perception and responding differ.

Overall, about half of the motorcycle riders involved in casualty crashes in Victoria in 1997-2001 were involved in collisions with vehicles. These collisions comprised 64% of crashes in low speed areas, 54% of crashes in higher speed metropolitan areas and 23% of crashes in higher speed areas in the Rest of Victoria. The most common types of collisions with vehicles were: turning right through, not at intersection, adjacent directions: right near (at intersection), head-on, not overtaking, rear-end impact and U-turns. It is likely that the other road user failed to give right of way to the motorcyclist in the majority of these crashes.

The crash patterns differ according to the age and licence status of riders. Older fully-licensed riders had more crashes in higher speed zones outside of the metropolitan area (and perhaps in higher speed zones inside the metropolitan area), which may reflect a pattern of recreational riding. Even within a given riding environment, age and licence status appear to affect the crash pattern. Older new riders (learner and probationary riders) were less likely to have collisions with vehicles and were more likely to have single vehicle crashes than other riders in low speed riding environments and in higher speed areas outside of the metropolitan area.

The interpretation of these crash data in terms of hazard perception and responding is difficult for the reasons outlined earlier. While the crash data suggest that hazards associated with the behaviour of other road users are most important, the crash data system provides little scope for identifying the presence or role of road based hazards in crashes.

RESEARCH INTO HAZARD PERCEPTION AND RESPONDING BY MOTORCYCLISTS

While there has been extensive research into hazard perception by car drivers since about 1990, relatively few studies have measured hazard perception and responding by motorcyclists.

Types of hazards reported by motorcyclists

Armsby et al. (1989) reported a study that sought to compare the effectiveness of different techniques for assessing drivers' perceptions of hazards using three types of interview methods, the Q-sort technique and several variants of the repertory grid method. All participants held a full driving licence. Regardless of whether nondirective, focussed or critical incident interviews were conducted, over 70% of the hazards mentioned by car drivers with no motorcycle riding experience arose from the behaviour of other road users, rather than features of the road environment. Car drivers who also rode (or had ridden) motorcycles, however, were able to identify specific features of the road, and specific actions of other road users, as hazards to motorcyclists. They conclude that "this might be expected, given that motorcyclists are more at risk from physical deficiencies in the road environment, such as a road surface with low skid resistance, and more vulnerable to injury if they are involved in an accident" (p.56).

Rider performance on car driver hazard perception test

In the United Kingdom, Horswill and Helman (2001) conducted a series of studies that attempted to assess the relative contributions of rider behaviour and car driver behaviour towards motorcycles and the physical vulnerability of motorcycles to the increased crash and injury rates of motorcycles compared to cars. Their first study compared the performance of three groups:

- Car drivers who had no (or almost no) riding experience
- Motorcycle riders who were asked to respond as if they were riding their normal motorcycle
- Motorcycle riders who were asked to respond as if they were driving their usual car.

The three groups were matched in terms of age, gender, total distance travelled per year and the proportion having undergone advanced training. The average age was

40 years, there were more males than females and about 45 percent had undertaken advanced training.

The participants completed a battery of video-based tests of driving behaviour and performance in the Reading University driving simulator. Those participants who were asked to respond as if they were driving their usual car sat in a car mock-up (with seat, steering wheel, and pedals mounted on a platform). Those participants who were asked to respond as if they were riding their usual motorcycle sat on a Suzuki B120 motorcycle mounted in a stabilising frame. Digital video stimuli were presented on the back projection screen and, where appropriate, participants responded to events on the video with a hand-held button (which allowed reaction times to events to be measured). In the terms used in this paper, the study measured hazard perception, but not the response selection or execution components of hazard perception and responding.

On McKenna's hazard perception test, motorcyclists responding as if they were driving their normal cars reacted faster to hazardous situations than either car drivers or motorcyclists responding as if they were riding their normal motorcycles. This would suggest that motorcyclists had better hazard perception skills than car drivers. Given that the hazard perception test was intended for car drivers, the researchers argue that some of the hazards might be less relevant for motorcyclists and that this might explain why this group did not perform as well on motorcycles as they did in cars.

Visual scanning patterns of riders and drivers

Few studies have compared the visual scanning patterns of riders and drivers. Nagayama, Morita, Miura, Watanabem & Murakami (1980) found that, compared to car drivers, motorcyclists had a wider vertical distribution of fixations and looked frequently at both near and far road surfaces. Whereas motorcyclists' fixations were more frequently on the road surface, car drivers looked relatively far ahead at objects such as traffic lights, and seldom at the road surface.

The differences in visual scanning patterns between motorcyclists and car drivers seem to be consistent with the types of crashes they have and with the nature of the riding/driving task itself. For example, given that motorcyclists ride on the outside of the road where they are more likely to encounter hazards such as uneven pavement surfaces, comparatively more of their attention is directed towards the road surface. This leaves little time to scan the distant foreground.

Tofield and Wann (2001) compared the scanning patterns of a group of 12 car drivers and a group of 12 motorcyclists. In contrast to Nagayama et al (1980), they found that motorcyclists looked significantly further down the road than car drivers. Tofield and Wann suggest that motorcyclists exhibited a pattern of scanning that is consistent with safe driving, whereas the pattern by car drivers could potentially lead to hazardous outcomes.

The inconsistency in the findings of these studies may reflect differences in the types of methodologies used and suggests that further research is needed to clarify any differences in scanning patterns between motorcyclists and car drivers.

IMPLICATIONS FOR MOTORCYCLIST HAZARD PERCEPTION TRAINING AND TESTING

Improving hazard perception skills can potentially lower the crash risk for all road users. However, teaching how to respond appropriately may be more critical for riders than for drivers because failures in responding may result in a failure to avoid the initial hazard or a different type of crash. While research has shown that hazard perception training in novice drivers leads to improved performance on hazard perception tests, it is not yet known whether these drivers go on to be safer drivers and have fewer accidents.

Most approaches to hazard perception training for car drivers require only detection of the hazard and responding by pressing a button. They do not train improved responding to hazards, which is of greater importance to riders than drivers.

Most available hazard perception tests do not measure whether the correct response is chosen or implemented – the focus is on the detection of the hazard only. In addition, the tests may not give sufficient emphasis to hazards specific to riding, particularly road surface hazards. This may limit the extent to which such tests are able to predict the crash risk for riders.

No rider-specific hazard perception test has been developed or introduced anywhere in the world. At present, it appears that there are no plans to introduce a separate version of the test designed specifically for riders in any jurisdiction. In the United Kingdom, candidates for a motorcycle licence are required to pass the car Hazard Perception Test (HPT), but this is not the case in Victoria, Western Australia and New South Wales. Most of the Victorian applicants for a motorcycle licence are not required to sit the car Hazard Perception Test because they already hold a car licence and it is assumed that they would have passed the Test (those who obtained their car licence after 1996) or would have developed hazard perception skills from years of driving cars. One study suggests riders are disadvantaged by the current UK licensing system that requires learners applying for their motorcycle licence to pass the HPT designed for car drivers. The authors recommend that a separate HPT for riders with associated training should be developed and introduced into licensing systems.

References

Allardice, G. (2002). *The biker's bible. Fun and survival on road-going motorcycles*. Wellington, NZ: Grant Sheehan, Phantom House Books.

Armsby, P., Boyle, A.J. & Wright, C.C. (1989). Methods for assessing drivers' perception of specific hazards on the road. *Accident Analysis & Prevention, 21*, 45-60.

Benda, H.V. & Hoyos, C.G. (1983). Estimating hazards in traffic situations. *Accident Analysis & Prevention, 15,* 1-9.

Crick, J. & McKenna, F.P. (1992). Hazard perception: Can it be trained? *Proceedings of Manchester University Seminar: Behavioural Research in Road Safety 2.*

de Rome, L., Stanford, G. & Wood, B. (2002). *MCC Survey of Motorcyclists.* Motorcycle Council of NSW.
Endsley, M.R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors, 37*, 32-64.
Evans, T. & Macdonald, W. (2002). Novice driver situation awareness and hazard perception. An exploratory study. *Paper presented at the Road Safety Research, Policing and Education Conference, Adelaide, 2002.*
Grayson, G.B., Maycock, G., Groeger, J.A., Hammond, S.M. & Field. (2003). *Risk, hazard perception and perceived control*. TRL Report TRL 560. Crowthorne: Transport Research Laboratory.
Harrison, W.A. (2002). What can parrots tell us about acquiring hazard perception skills? In *The Australian College of Road Safety, Developing Safer Drivers and Riders, Conference Proceedings, Brisbane 21-23 July 2002.* Canberra: The Australian College of Road Safety, pp.1-11.
Haworth, N., Symmons, M. & Kowadlo, N. (2000). *Hazard perception by inexperienced motorcyclists.* Report No. 179. Melbourne: Monash University Accident Research Centre.
Haworth, N., Smith, R., Brumen, I. & Pronk, N. (1997). *Case control study of motorcycle crashes.* (CR 174). Canberra: Federal Office of Road Safety.
Horswill, M.S. & Helman, S. (2001). A comparative approach to differential accident liability: Motorcyclists versus car drivers. In Grayson, G.B. (Ed), *Behavioural Research in Road Safety: Eleventh Seminar.* London: Department of Environment, Transport, and the Regions.
Hurt, H.H., Ouellet, J.V., & Thom, D.R. (1981). Motorcycle accident cause factors and identification of countermeasures. Volume 1: Technical Report, Washington, D.C: US Department of Transportation, National Highway Traffic Safety Administration. HS-5-01 160.
Klein, G.A. (1993). A recognititon-primed decision (RPD) model of rapid decision making. In Klein, G.A., Orasanu, J., Calderwood, R. & Zsambok, E. (Eds.), *Decision making in action: Models and methods*. Norwood, NJ: Ablex.
Lynam, D., Broughton, J., Minton, R. & Tunbridge, R.J. (2001). *An analysis of police reports of fatal accidents involving motorcycles*. TRL Report 492.
Nagayama, Y., Morita, T., Miura, T., Watanabem, J. & Murakami, N. (1980). *Motorcyclists' visual scanning pattern in comparison with automobile drivers'*. Society of Automotive Engineers.
Ouellet, J. (1982). Lane positioning for collision avoidance. An hypothesis. *Proceedings International Motorcycle Safety Conference 1990.* Florida, USA.
Royal Society for the Prevention of Accidents (RoSPA). (2001). *Motorcycling Safety Position Paper (2001).*
Tofield, M.I. & Wann, J.P. (2001). Do motorcyclists make better car drivers? *Proceedings of Psychological Post-graduate Affairs Group Conference*. Glasgow, Scotland.