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Hazard perception of motorcyclists and car drivers

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ABSTRACT

The current study compares hazard perception (HP) performance of 50 male drivers with and without a motorcycle license in order to generalize results. A video-based HP test, measuring reaction times to traffic scenes, was administered to these two groups of drivers. Participants with a motorcycle license performed better than participants without a motorcycle license. ANOVA indicated that learning improved linearly for participants with a motorcycle license but not for participants without a motorcycle license. No evidence that HP was predicted by age was found. HP scores for drivers who reported previous involvement in an accident were lower than for those who reported not being involved in an accident. The results are discussed in the context of sensitivity and response bias models.

1. Introduction

Motorcycle riders have especially high rates of injury in the USA (NHTSA, 2007) and in many other countries (for example, in Israel, National Authority of Road Safety, 2008). Potential harm is greater for motorcyclists and their passengers than for vehicle drivers since they are not protected by the metal structure of a vehicle (Shu-Kei Cheng and Chi-Kwong Ng, 2010).

Haque et al. (2009) showed that motorcycle drivers are at fault in a number of critical situations, in particular, high speed riding on expressways, riding with pillion passengers on expressways, and riding on wet-road surfaces. These findings are the basis for the rationale of the current study, aimed to better learn the capacities of motorcyclists to cope with dangerous traffic situations compared to those of car drivers.

Mannering and Grodsky (1995) give several reasons why the characteristics of motorcycle accidents differ from those of other vehicles. First, they claim, car drivers “tend to be inattentive with regard to motorcyclists and have conditioned themselves to look only for other [cars] as possible collision dangers.” Second, they claim that motorcycle operation is typically a more complex task than driving a car, requiring excellent motor skills, physical co-ordination and balance. Motorcycle riding also involves counterintuitive skills such as “counter-steering, simultaneous application of [mechanically separate] front and rear brakes, and opening the throttle while negotiating turns.” Riding behaviors that have been found to increase crash risk include riding too fast (e.g. Lin et al., 2003; Wells, 1986), drink-riding (e.g., Fell and Nash, 1989; Lin et al., 2003), poor observation as well as poor signaling at junctions (e.g., Wells, 1986).

Since motorcycle riders are subject to specific hazards in addition to those that they have in common with car drivers, this article is concerned with hazard perception of motorcyclists as compared to car drivers.

For car drivers, anticipation of hazardous traffic situations is perhaps one of the major contributions to driver safety, although Sagberg and Bjørnskau (2006) concluded that hazard perception is probably only a minor factor in explaining the initial risk decrease among novice drivers. A hazard is defined as any permanent or transitory, stationary or moving object in the road environment that has the potential to increase the risk of a crash (Haworth et al., 2005). Hazard perception is defined as “the process whereby a road user notices the presence of a hazard” (Haworth and Mulvihill, 2006). Since hazard perception predicts crash risk (Haworth and Mulvihill, 2006), it is justified to emphasize it in order to reduce injury in road crashes. The current study focuses on hazard perception of motorcyclists and car drivers.

Hazard perception is a multi-component cognitive skill that can improve with experience (Deery, 1999). This set of skills, usually measured by the Hazard Perception Test (HPT), was found in previous studies to be better in experienced drivers (Crundall et al., 1999, 2002; Horswill and McKenna, 2004; Sagberg and Bjørnskau, 2006). Furthermore, Smith et al. (2009) found a significant interaction between sleepiness and experience, indicating that the hazard perception skills of the more experienced driver was relatively unaffected by mild increases in sleepiness while in the inexperienced driver, the skills were significantly weaker.

As hazard perception has been considered an important component of safe driving, the performance of motorcyclists on the HPT was tested and compared to that of car drivers. Motorcycle riders

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function differently from car drivers in hazard perception as well as in other traits. In particular, in a study by Horswill and Helman (2003), participants completed a battery of video-based tests of driving behavior and performance in a video-based car or motorcycle simulator. In the HPT, participants were shown various road situations and asked to push the reaction key as rapidly as possible when they detected a potentially hazardous situation developing on the road in front of them. The motorcyclists succeeded better in the hazard perception task than the car drivers. While this advantage was obtained when they were imagining they were driving a car, it was not present, however, when they were asked to imagine they were on a motorcycle.

Horswill and Helman's (2003) conclusion was that the influence of motorcyclists' behavior on their accident risk is small. Due to the increasing involvement of motorcyclists in road crashes (Broughton et al., 2009), we believe it is important to explore more about the different HP patterns of motorcyclists compared to those of car drivers.

The current study focuses on this issue involving a different test as well as participants from a different country with different characteristics in order to obtain a higher degree of generalization of the results of Horswill and Helman's study (2003).

2. Method

2.1. Participants

Fifty male drivers, students in the Rishon Letzion College in Israel, recruited through advertising in a student internet site, volunteered to participate in the study (mean age = 27.4; S.D. = 3.0 range = 21–31). Half of the participants had a motorcycle license (mean age = 28.5; S.D. = 3.2) and half of the participants did not (mean age = 25.9; S.D. = 3.2). All the participants had a vehicle driving license. The two groups did not differ either in their family status or in number of children [$\chi^2 = 0.39$, $p > .1$; 0.14, $p > .1$, respectively]. The information obtained came from self-reports and most of the participants were Israeli-born, their residence was in the center of the country, and they were all in good physical condition.

2.2. Instruments

Two instruments were used for this test:

1. *The Hazard Perception Test*. This test was developed for training purposes for novice drivers, not yet in use as an official test that all drivers must complete to gain a driving license. Bearing resemblance to the tests used in the UK (Driving Test 2007/08), this test consisted of 10, randomly presented 1-min video clips containing naturally occurring traffic situations. Any situation which could potentially develop into a hazard was considered a critical situation in the test. The situations included daylight vs. nighttime, rainy vs. sunny weather, etc. All the participants were exposed to the same clips, although in different random order.

Some clips show a sudden occurrence, such as a pedestrian running into the road or a vehicle making a sudden turn without warning, a traffic light turning red or a vehicle suddenly switching from one lane to another. When the participant notices the oncoming danger, s/he has to click on the mouse. Each click on the mouse is registered. During the test, the participant does not receive feedback about misses or hits. S/he gets a score from 1 to 5 (where 1 is low and 5 high) after each clip. This score is determined by (1) the time reaction to the danger measured by the click of the mouse (2) a false alarm – clicking the mouse in a non-danger situation and (3) missing the danger, measured by not clicking the mouse when expected.

Test Scoring: The Hazard Perception Test includes 14 (of which we presented 10) driving video clips viewed from the driver's point of view. Each of the clips contained a transportation situation that required either slowing down, stopping or lane changing due to the hazard presented. The subjects were asked to indicate these hazards by a mouse click. Most of the video clips contain one hazard only. One of the video clips contains two hazards (and participants are informed of such). There is no indication which of the video clips contains the double hazard. This means that participants must watch every video from start to finish and not “lose interest” once he thinks he has spotted the hazard. Each video clip lasts around 1 min.

As each video clip has been carefully analyzed, the exact moment when the hazard can first be spotted is recorded. At the other end of the scale, the last possible moment when the driver could be seen as having reacted to the hazard “in time” is recorded as well. Depending on the clip, this time frame can vary in length from a second to 10 s or more. The clip is divided up into 5 equal-length scoring sections. If the participant responds to the hazard in the first of the 5 sections, he scores 5 points. If participant responds in the second of the time segments, he scores 4 points, and so on.

There is no upper limit on the number of times a participant can click during a clip but the software contains an algorithm to detect and eliminate “cheat” clicking. The software monitors for patterned, rapid and numerous clicks. Candidates who try to cheat by clicking once a second throughout a clip will not get any points for that video clip and will receive an on-screen warning. The Cronbach's alpha of the test is .8434.

2. *The Demographic Questionnaire*. This questionnaire contained 22 questions concerning age, gender, marital status, residence and details about the participant's driver's license (vehicle and/or motorcycle), ownership of the vehicle and/or a motorcycle, responsibility of involvement in accidents and fines received from the traffic police.

2.3. Procedure

The participants were invited to a session of the Hazard Perception Test (HPT) at the College of Management in Rishon Letzion and at the Institute of Technology in Holon. They filled out the above-mentioned questionnaire, after which they each took the Hazard Perception Test.

Participants were exposed to the HPT after being briefed about the task, as detailed above. Hazardous situations were defined as any situation where the driver needed to suddenly brake or execute any other maneuver to avoid a collision. Scores for each test were calculated by two parameters: (1) Response time after the appearance of a precursor of a critical situation (participants were given higher scores for faster responses). (2) In case of a false choice (responding without a hazardous event), the participant lost points.

The Score Sheet. All 10 scores were registered for each participant individually.

3. Results

The means of the HPT score were submitted to an independent sample *t*-test in order to investigate the prediction that the motorcyclist would perform better in the HP test. As presented in Table 1, motorcyclists indeed performed better. We also found that this pattern of results was true when we performed the analyses separately for different age groups (22–27 years vs. 28–30 years), for participants that had been involved in an accident vs. participants that had not been involved in an accident, for participants that received fines (one or more) vs. participants who received no fines, and for differ-

Table 1
Hazard perception scores for motorcycles drivers vs. car drivers.

		N	Mean	S.D.	*t*	*p*
Groups	**Motorcyclists**	**35**	**3.81**	**.33**	**−12.62**	**.001**
	Car drivers	**25**	**2.60**	**.41**		
Age: 22–27 years	Motorcyclists	14	3.79	.34	−8.39	**.001**
	Car drivers	18	2.61	.44		
Age: 28–39	Motorcyclists	21	3.83	.34	−8.26	**.001**
	Car drivers	7	2.58	.38		
Involvement in accident	Motorcyclists	21	3.93	.29	−6.98	**.001**
	Car drivers	8	2.93	.47		
No accident	Motorcyclists	14	3.64	.32	−11.03	**.001**
	Car drivers	17	2.44	.28		
Have tickets	Motorcyclists	15	3.77	.39	−8.65	**.001**
	Car drivers	15	2.54	.39		
No tickets	Motorcyclists	20	3.85	.29	−8.57	**.001**
	Car drivers	10	2.69	.45		
License 0–7 years	Motorcyclists	13	3.97	.24	−7.58	**.001**
	Car drivers	9	2.70	.54		
License 8+ years	Motorcyclists	22	3.72	.35	−1.53	**.001**
	Car drivers	16	2.55	.33		

ent number of years driving private cars (0–7 years vs. 8+ years). The HP scores of car drivers who were not involved in an accident ($M = 3.04$, S.D. = .54, $N = 9$) were higher compared to the scores of car drivers who were involved in an accident ($M = 2.60$, S.D. = .53, $N = 19$), $t(26) = 2.06$, $p < .05$; whereas the HP scores of motorcyclists did not significantly differ between those who were not involved in an accident ($M = 3.89$, S.D. = .39, $N = 11$), and those who were involved in an accident ($M = 3.77$, S.D. = .32, $N = 21$), $t(30) < 1$.

In line with the introduction and in order to investigate the learning capability for the two groups, the means of the HPT scores were submitted to a two-way mixed model analysis of variance (ANOVA) by group (motorcyclist and non-motorcyclist) as a between-participants factor and clips as a within-participants factor. We found (Fig. 1) that participants with a motorcycle license performed better in the HPT than participants without a motorcycle license [$F(1, 58) = 159.20$, $p < .05$, $\eta_p^2 = .73$].

In addition, we found that participants improved their performance with time. In particular, there was a difference between clips [$F(9, 52) = 2.86$, $p < .05$, $\eta_p^2 = .05$]. A significant interaction between Motorcycle License (having vs. not having) and Test (Test 1–10) was found [$F(9, 522) = 2.84$, $p < .05$, $\eta_p^2 = .05$]. We also found that learning was indicated by the linear increase in performance in the test with clips in the HPT score for participants with a motorcycle license [$F(1, 34) = 33.30$, $p < .05$, $\eta_p^2 = .50$] but not for participants without a motorcycle license [$F(1, 24) = 1.55$, $p > .1$, PES = .06]. The

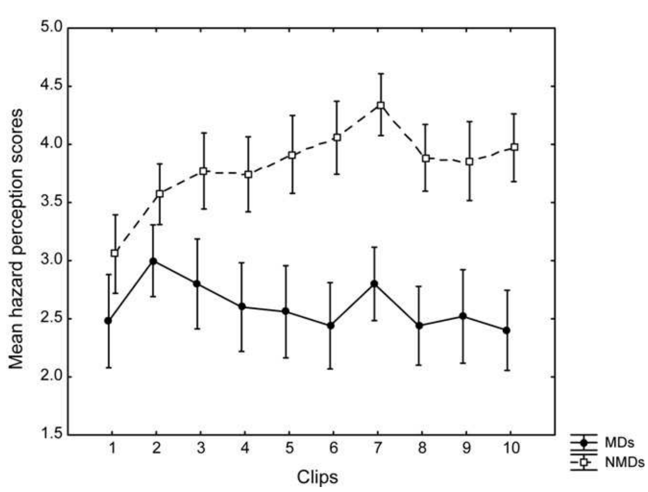

Fig. 1. Mean score as a function of order of test (1–10) of motorcycle drivers (MDs) and non-motorcycle drivers (NMDs). Error bars: ±2 S.E.

analysis of the differential scoring of the two groups, as well as the results, was post-hoc.

4. Discussion

The current study was addressed to better learn the capacities of motorcyclists to detect dangerous traffic situations compared to those of car drivers. The results are of great importance especially when considering the relatively higher vulnerability of motorcyclists (Broughton et al., 2009).

As reflected by the findings of the current study, motorcyclist drivers (MDs) demonstrated better performance on a Hazard Perception Test than non-motorcycle drivers (NMDs). These results are consistent with a previous study (Horswill and Helman, 2003), indicating better HP amongst motorcyclists, thus strengthening the ability to generalize the findings of Horswill and Helman (2003) to other societies and conditions.

In addition to our original purpose, we discovered that the HP performance of motorcycle-licensed participants improved more than that of participants without a motorcycle license, which may indicate the ability for a better learning process of road hazards by motorcycle-licensed drivers than non-motorcycle licensed drivers. We can make a conjecture that motorcyclists learn faster as they are, perhaps, subject to unique hazards in addition to those that they have in common with car drivers (Haque et al., 2009). Indirect support of this phenomenon is given in a recent work of Hosking et al. (2010). They found that experienced drivers with a license for both a motorcycle and a car exhibited the most flexible visual scanning patterns, i.e. they were sensitive to the presence of road hazards and identified hazards faster than did all the other participants (experienced car drivers vs. inexperienced drivers). This may indicate that there is an accumulative contribution of general driving experience as well as specific experience in motorcycling to better performance in hazard perception.

Another explanation for the faster learning patterns of road hazards by motorcyclists may come from the experiments of Wallis and Horswill (2007). They assert that individual differences in hazard perception are the results of some drivers being less able than others to distinguish the anticipatory cues in more hazardous situations from those in less hazardous situations. In this context, “hazardousness” is the probability that a collision or a close-to-collision with another road user will happen if no action is taken by the driver. According to this model, novice drivers, for example, tend to miss anticipatory cues, leading them to misclassify the possibility for a traffic conflict to take place. If we develop this kind of thinking, motorcyclists who are exposed to a larger range of hazards (Haque et al., 2009; Lin et al., 2003) must adopt a lower criterion for hazards (namely, to adopt a lower threshold of perceived hazardousness to which drivers respond) in order to survive. They therefore learn faster than others to identify anticipatory cues in more hazardous situations.

Hazard perception, in the current study, was predicted by involvement in an accident, as reported in the demographic questionnaire. It is possible that lower ability of hazard perception leads to involvement in accidents (in agreement with Haworth and Mulvihill, 2006).

Summing up, based on our present study and the previous one (Horswill and Helman, 2003), we may conclude that there is at least some evidence that motorcyclists have better hazard perception than non-motorcyclists. The reason for this is yet unclear and could be due to different kinds of on-the-road exposure that motorcyclists experience while driving compared with car drivers. More research is needed to understand the exact cause.

Some methodological remarks need to be taken in consideration. It was almost impossible to find more than 10 participants who have a driving licenses only for motorcycles, as in Israel most people get their driving license at the ages of 18–22. We did not want to deal with teenagers as we wanted to avoid the novice drivers' syndrome. So, as a compromise, we took those who had a driving license for both a vehicle and a motorcycle. The condition for participation was that the participant owned only a motorcycle and that it had been used frequently in the previous 3 years.

Another limitation is due to the participation of male drivers only. Since gender differences regarding safe driving are well known in literature (for example, Dewar and Olson, 2007), it is recommended to involve both males and females in the experimental group as well in the control group.

One of the factors that distinguish motorcyclists from car drivers is probably a demand for increased functioning while driving. Interestingly, Crundall et al. (1999) asked participants to search video clips taken from a moving driver's perspective for potential hazards while responding to peripheral target lights. Hit rates for peripheral targets decreased as processing demands increased.

Practical implications deriving from this study refer to the controversial issue of the effectiveness of motorcyclists' training. Although formal driver training should increase riding skills and reduce the risk of motorcycle crashes and injuries, riders who received training had no significant reduction in the risk of motorcycle crashes compared with those who did not go through a training course (Rutter and Quine, 1996). However, this refers especially to young drivers, while the participants in the current study were around the age of 27.

More research is needed to investigate if the differences between motorcyclists and non-motorcyclist drivers are a result of differences in the pattern of eye movements. The analysis of eye movements can provide rich information about a driver's attention and the course of behavior in hazardous situations (Velichkovsky et al., 2002). It is possible that motorcyclists and car drivers differ in their pattern of eye movements in the same way that different groups, for example, police drivers, are typified by different patterns of eye movements (Crundall et al., 2003). Accordingly, it is possible that motorcyclists develop different patterns of eye movements that help them in the task of hazard perception.

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