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A behavioral comparison between motorcyclists and a matched group of non-motorcycling car drivers: factors influencing accident risk

Mark S. Horswill*, Shaun Helman

Department of Psychology, University of Reading, Reading RG6 6AL, UK

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Abstract

Motorcyclists and a matched group of non-motorcycling car drivers were assessed on behavioral measures known to relate to accident involvement. Using a range of laboratory measures, we found that motorcyclists chose faster speeds than the car drivers, overtook more, and pulled into smaller gaps in traffic, though they did not travel any closer to the vehicle in front. The speed and following distance findings were replicated by two further studies involving unobtrusive roadside observation. We suggest that the increased risk-taking behavior of motorcyclists was only likely to account for a small proportion of the difference in accident risk between motorcyclists and car drivers. A second group of motorcyclists was asked to complete the simulator tests as if driving a car. They did not differ from the non-motorcycling car drivers on the risk-taking measures but were better at hazard perception. There were also no differences for sensation seeking, mild social deviance, and attitudes to riding/driving, indicating that the risk-taking tendencies of motorcyclists did not transfer beyond motorcycling, while their hazard perception skill did.

Keywords: Driver behavior; Motorcyclist behavior; Risk taking; Speeding; Hazard perception

1. Introduction

In the UK (1997–1999), motorcycles were 9.3 times more likely than cars to be involved in an injury or fatal accident, controlling for time spent travelling (Horswill and Helman, 2001). Controlling for distance traveled, over the same time period, motorcycles were 7.9 times more likely than cars to be involved in such accidents. The focus of the present investigation is the role that motorcyclists' own behavior plays in inflating their accident risk compared with car drivers.

A number of key driving behaviors have been found to discriminate between accident-involved and accident-free drivers, including speed choice (Wasielewski, 1984; Wilson and Greensmith, 1983), car following distance (Evans and Wasielewski, 1983), overtaking propensity (Wilson and Greensmith, 1983), self-reported driving violations (Parker et al., 1995), and the ability to perceive hazardous situations in the road ahead (McKenna and Horswill, 1999; Quimby et al., 1986). Our objective was to determine the extent to which motorcyclists and car drivers differ on these key accident-related behaviors. Previous research into motorcyclists' behavior has not involved direct comparisons with other road user groups. The lack of a comparison limits the interpretation of findings. For example, although it has been found that young male motorcyclists are at a higher risk of being involved in an accident than other motorcyclists (Chesham et al., 1991), the same is also true of young male car drivers compared with other car drivers (Maycock et al., 1991). The motorcyclist population in the UK is more male-dominated and younger than the car driver population. This pattern emerges for (1) mileage per person per year (Department of Transport, 1993, Table 2.6), (2) number of journeys per person per year (Department of Transport, 1993, Table 2C), and (3) proportion of individuals who either drove a car or rode a motorcycle during a sample week (collapsed data from 1992 to 1999 of the National Travel Survey; Broadley, 2001). Therefore, if we compare a random sample of motorcyclists with a random sample of car drivers, we may find that the motorcyclists take more risks, but it would not be clear the extent to which this was due to motorcyclists being younger and male, given that young males tend to take more risks on the road in any case (Evans, 1991). Is there a pattern of accident-related behaviors specific to motorcyclists that can account, or at least partly account, for the difference in accident risk between motorcyclists and car drivers, controlling for demographic factors?

* Corresponding author. Tel.: +44-118-987-5123x7530; fax: +44-118-931-6715.
E-mail address: m.s.horswill@reading.ac.uk (M.S. Horswill).

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In the present series of studies, we compared motorcyclists with demographically-matched groups of car drivers on a range of accident-related behavioral and attitudinal measures, using a number of alternative methods.

2. Study 1

In this study, we measured the behavior of motorcyclists on motorcycles, motorcyclists in cars, and a matched group of non-motorcycling car drivers in cars. If motorcyclists on motorcycles are found to take more risks than car drivers in cars then one question of interest is whether these differences are a characteristic of the type of person who rides motorcycles (controlling for demographics) or whether motorcyclists are, in general, the same as other road users and only take these additional risks when riding a motorcycle.

Certain attitudes have also been found to relate to accident involvement, e.g. self-reported attitudes to driving (West and Hall, 1997). Also behaviors not specific to driving such as mild social deviance have been found to relate to accident involvement (West et al., 1993a; West and Hall, 1997). If motorcyclists represent a qualitatively different type of person, we might expect them to differ from car drivers in terms of their attitudes and also on behaviors not specific to motorcycling.

2.1. Method

2.1.1. Sample

One hundred and six UK motorcyclists completed a battery of laboratory tests and questionnaire measures that related, or were thought to relate, to accident involvement. Fifty were asked to respond as if they were riding their usual motorcycle and 56 as if they were driving their usual car. A further 56 UK car drivers were asked to complete the tests as if they were driving their usual car. These car drivers had no (or, in the case of two participants, negligible) motorcycle experience. We did not test non-motorcycling car drivers on motorcycles as they would have been making purely hypothetical reports of their behavior in contrast to the other three groups. The reason we tested two separate groups of motorcyclists, rather than have one group undergo the tests twice (once as a motorcyclist and once as a driver) was because we were concerned that repetition of the tests may have influenced responses.

Participants were recruited by (1) sending e-mails to companies, university staff, and some university students, (2) placement of advertisements in motorcycle shops and a local newspaper, (3) word of mouth via motorcyclists' and drivers' clubs. Participants were paid 15 GBP for participating. Our recruitment was targeted in an attempt to match the three groups on five key variables relating to demographics and motoring experience/exposure: age, gender, time since participants passed the UK car or motorcycle test (if participants had passed both tests, we used the time that was greater), annual mileage (motorcycle and car mileage totaled), and whether participants had undergone advanced driver/rider training. Our criterion for matching was that the three groups should not differ significantly at the 5% level despite there being reasonable power (75%) to detect a medium-sized difference for the continuous variables ($f = 0.25$, see Cohen, 1992) or a medium-sized association with group ($w = 0.3$, see Cohen, 1992) for the discrete variables (gender and advanced training).

An initial analysis revealed differences between the groups based on our criterion. We found that the deletion of 20 individuals' data removed these differences and so all analyses were carried out on this revised sample. There were 47 motorcyclists who completed the tests as if on their motorcycle, 47 motorcyclists who completed the tests as if in their car, and 48 non-motorcycling car drivers who completed the tests as if in their car. A MANOVA revealed no overall difference between the groups over the five variables, $F(10, 256) = 1.56$, $P = 0.12$ (see Table 1 for the values of the matching variables across groups, with associated significance tests).

It should be noted that while our sample was younger than the estimated mean UK driver age of 46 years (Broadley, 2001), our sample had higher mileage (e.g. mean mileage for UK male drivers has been estimated at 8160 miles per year between 1998 and 2000; Broadley, 2001). The proportion of those who had been involved in advanced driver/rider training was also high. In a previous sample of 687 UK drivers (unpublished data from the first author's laboratory), only 16% had undergone advanced driver training.

Table 1
Group means (standard deviations) on matching variables

	Motorcyclists on motorcycles ($n = 47$)	Motorcyclists in cars ($n = 47$)	Car drivers in cars ($n = 48$)	Significance (P)
Age	37.45 (10.17) years	41.11 (10.73) years	38.15 (11.87) years	0.26
Gender	37 males, 9 females	39 males, 8 females	33 males, 15 females	0.17
Time since passed UK car or motorcycle test	18.79 (20.55) years	23.00 (11.37) years	19.89 (11.30) years	0.32
Annual mileage	16403 (8327) miles	16017 (6547) miles	13083 (8271) miles	0.10
Advanced driver/rider training	19 trained, 28 no training	22 trained, 25 no training	19 trained, 28 no training	0.14

2.1.2. Materials and procedure

Participants completed a battery of video-based tests of driving behavior and performance in a video-based car/motorcycle simulator. The simulator consisted of a blacked-out cubicle, in which participants were positioned 2 m from a 1.42 m × 1.07 m back projection screen. Participants responding as if they were driving their usual car sat in a car mock up, with seat, steering wheel, and pedals mounted on a platform (the controls were inoperative). Participants responding as if riding their usual motorcycle sat on a Suzuki B120 motorcycle mounted in a stabilizing frame. Participants' eye height and their distance from the screen was the same for both vehicle types. Digital video footage of traffic situations was projected onto the screen and, where appropriate, participants responded to events on the video with a hand-held button. Response latencies were measured via a computer with timing software, which was keyed into specific events on the video. The following tests were used.

2.1.2.1. Hazard perception test (McKenna and Crick, 1994; McKenna and Horswill, 1999). Participants were shown a drivers' eye view of various road situations and asked to press the response button as soon as they detected a potentially dangerous situation developing on the road ahead. Response latencies to eight selected hazards were measured and the average taken to give an overall hazard perception score. When participants missed a particular hazard altogether, they were assigned a response latency for that hazard three standard deviations slower than the mean for a stratified sample of UK drivers. This test has been found to relate to accident involvement and can discriminate between novice, experienced, and expert drivers.

2.1.2.2. Video close-following test (Horswill, 1994; Horswill and McKenna, 1999a,b). Participants were shown footage of a motorway, in which the camera car approached the back of a car in front. They were asked to press the response button when they reached their normal following distance from the car in front and again when they reached the following distance at which they felt 'uncomfortably close'. For the present study, 12 different scenes were filmed. Two scores were generated: (1) a mean of the response latencies of the 12 'normal' following distance responses and (2) a mean of the 12 'uncomfortably close' following distance responses (higher the response latency, the shorter the following distance).

2.1.2.3. Video gap acceptance test (Horswill, 1994; Horswill and McKenna, 1999a,b). Participants were shown a view from an unsignalized intersection as if they were about to merge with a stream of traffic. They were asked to press the response button at any point that they would be willing to pull out into the stream of traffic. The footage of the oncoming stream of traffic was edited to include 60 gaps of differing lengths between successive vehicles. The score was the total number of gaps accepted.

2.1.2.4. Video overtaking test. This test was devised for the present study. Participants were shown 30 scenes filmed from the perspective of a driver/rider who was following a slow-moving vehicle on a single-carriageway road. For each scene, they heard a recorded voice say, "press the button if you would overtake ... now". The word "now" was preceded by two tones placed a second apart to allow participants to anticipate the exact moment on the video that was being referred to. Participants pressed the response button if they would have overtaken at the moment indicated. If they would not have overtaken, they did not press the button. Scenes were chosen to give a range of overtaking opportunities that varied in the distance to an oncoming vehicle approaching in the opposite lane. Participants (including motorcyclists) were told to assume that if there was an oncoming vehicle in the opposite lane then they would not be able to fit down the middle of the road between the oncoming vehicle and the car in front of them. The overtaking score was the number of overtaking situations accepted.

2.1.2.5. Video speed test (Horswill and McKenna, 1999c). Participants were shown seven scenes filmed from a moving vehicle, and were asked to judge the extent to which they would normally drive/ride faster or slower than the vehicle in the video in miles per hour (mph). This test has been found to predict speed-related accident involvement.

After the video tests, participants were asked to complete a computer-based questionnaire, which consisted of the following measures, together with demographic and riding/driving experience measures. For all the questionnaire measures involving self-reports of driving/riding, motorcyclists who responded as if they were driving a car in the video tests were asked to respond to the questions with their car driving behavior in mind. Similarly, those motorcyclists who completed the video tests as if on a motorcycle were told to answer the questions as motorcyclists. The non-motorcycling car drivers responded to the questions as car drivers. The different groups received questionnaires with minor wording changes to reflect whether they were responding as motorcyclists or car drivers. The score for each questionnaire was the mean of drivers' responses to all the items (reversing scales where appropriate). Note that the two photographic animations were single item measures.

2.1.2.6. Three item questionnaire on speed choice (French et al., 1993; West et al., 1993b). This included questions such as "How often do you drive fast?" (*never or very infrequently* to *very frequently or all the time*).

2.1.2.7. Eight item driving violations questionnaire (Parker et al., 1995). This included items such as "How often do you cross a junction knowing the lights have already turned against you?" (*never* to *nearly all the time*).

2.1.2.8. Ten item social motives questionnaire (West et al., 1993a). This is a measure of mild social deviance, focusing on self-serving behavior that might harm the interests of others, e.g. "(How likely are you to) make a fraudulent insurance claim?" (*Not at all likely* to *very likely*).

2.1.2.9. Seven item attitudes to driving violations questionnaire (West and Hall, 1997). This included items such as, "penalties for speeding should be more severe" (*strongly agree* to *strongly disagree*).

2.1.2.10. Photographic animation measure of gap acceptance (Horswill and Coster, 2001). Respondents could animate a photograph of a single vehicle approaching along a major road from the perspective of a driver waiting to pull out from a minor road at an unsignalized junction. Participants were asked to select the shortest gap in front of the vehicle that they would be willing to pull out into.

2.1.2.11. Photographic animation of overtaking propensity (Horswill and Coster, 2001). Respondents were shown a photograph of a driver's eye view of a single carriageway road, in which the camera car was following a car in front and there was opportunity for overtaking. Respondents could animate the scene such that another vehicle travelling from the opposite direction drew closer. Respondents were asked to indicate the shortest headway to the oncoming vehicle they would consider using to overtake.

2.1.2.12. Photographic animation of close following (Horswill and Coster, in press). Respondents could animate a photograph taken from the perspective of a driver approaching the back of the car in front on a motorway. They were asked to select the distance at which they would normally follow the car.

2.1.2.13. Photographic measure of speed choice (Horswill and Coster, in press). Respondents were shown photographs of four road scenes (motorway/freeway, rural road, and two urban residential roads) and asked to indicate what speed in mph they would travel at in each situation.

2.1.2.14. Sensation seeking questionnaire—10-item intensity subscale (Arnett, 1994). This questionnaire has been found to relate more strongly to risk behavior than Zuckerman's sensation seeking scale (Zuckerman et al., 1978), while not containing any items relating to risk (unlike Zuckerman's scale).

After completing the questionnaire, participants were debriefed and paid.

2.2. Results

2.2.1. Preparation of variables

There were missing values for 1.30% for measures to be used in the multivariate analysis: 321 missing out of a total of 24,708 responses (142 participants with 174 responses each). There was no obvious pattern to these misses. Using a conservative strategy (Tabachnick and Fidell, 1983), missing values were replaced either by the sample means (hazard perception, following distance, video speed, and photographic speed) or the sample modes (gap acceptance, overtaking, and the remaining questionnaire measures).

All of the measures were tested for skew, and only the video gap acceptance measure had a skew >1 indicating that it was likely to differ significantly from a normal distribution (SPSS Inc., 1998). A square root transformation was found to reduce the skew of the gap acceptance measure to 0.43. All analyses on this measure therefore use the transformed variable.

Given that the video-based test of overtaking used was new, we were interested in its external validity. While this was difficult to assess directly due to a lack of recent observational work on overtaking, the significant relationship with age for the car drivers, $r = -0.33$, $n = 47$, $P = 0.025$, may reflect the statistic that young drivers have more overtaking accidents than older drivers as a proportion of all accidents (Department of Transport, 1993, Table 3e). The overtaking measure also correlated with other measures of risk taking known to relate to accident involvement, e.g. the speed questionnaire, $r = 0.40$, $n = 48$, $P = 0.004$, and the violations questionnaire, $r = 0.33$, $n = 48$, $P = 0.024$. There was also a correlation between the video measure of overtaking and the photographic animation of overtaking, $r = 0.63$, $n = 48$, $P < 0.0005$, indicating that they were measuring the same underlying construct to some degree.

2.2.2. Principle components analysis of behavioral and attitudinal measures

First, we carried out a principle components analysis with a Varimax rotation on the 15 measures taken in order to reduce them to fewer and more orthogonal components. This was to avoid problems of multicollinearity in the multivariate analysis. The measures grouped together as follows (factor loadings for variables >0.4; no measure loaded >0.4 onto more than one factor).

2.2.2.1. Factor 1 (speed/attitudes factor). Driving violations, attitudes to driving, social motives, speed questionnaire, photographic speed choice, video speed.

2.2.2.2. Factor 2 (overtaking/gap acceptance factor). Video overtaking test, overtaking animation measure, video gap acceptance test, gap acceptance animation.

2.2.2.3. Factor 3 (close-following factor). Video close-following test ('normal following distance'), video close-following test ('uncomfortably close following distance'), close-following animation measure.

There was a fourth factor, but this was not obviously interpretable (only sensation seeking and hazard perception loaded onto it, factor loading >0.4) and only accounted for

Table 2
Univariate effects of group on the attitudinal/attitudinal measures

Dependent variable	Effect of group
Speed/attitudes factor	$F(2, 139) = 14.33$, $P < 0.0005$
Overtaking/gap acceptance factor	$F(2, 139) = 21.09$, $P < 0.0005$
Close-following factor	$F(2, 139) = 0.42$, $P = 0.728$
Hazard perception	$F(2, 139) = 3.66$, $P = 0.028$
Sensation seeking	$F(2, 139) = 0.44$, $P = 0.697$

8.4% of the variance. Hence, sensation seeking and hazard perception were entered into the final MANOVA as separate components. Factor scores were constructed by obtaining z-scores of the measures that comprised the three factors and calculating a mean of these z-scores for each factor.

2.2.3. Multivariate analysis of behavioral and attitudinal measures

We carried out a MANOVA, with experimental group (motorcyclists on motorcycles, motorcyclists in cars, car drivers in cars) as the independent variable, and the three factors (speed/attitudes, overtaking/gap acceptance, close-following) plus hazard perception and sensation seeking as the five dependent variables. There was a multivariate effect of group, $F(10, 272) = 5.99$, $P < 0.0005$. The univariate effects of group on the five dependent variables can be seen in Table 2 and the outcomes of Student–Newman–Keuls (S–N–K) post hoc tests can be seen in Table 3.

Motorcyclists on motorcycles were more risky than motorcyclists in cars and drivers in cars for both the speed/attitudes factor and the gap acceptance/overtaking factor. Motorcyclists in cars were less risky than car drivers in cars for the gap acceptance/overtaking factor, though they did not differ on the speed/attitudes factor. In order to see whether the behavioral or the attitudinal measures were responsible for the group differences for the speed/attitudes factor, we calculated a speed factor (video speed, questionnaire speed, and photographic speed). This factor, and the violations measure, reflected the same pattern of group differences as the overall speed/attitudes factors. However, there were no significant differences between the three groups for the social motives and the attitudes to driving/riding questionnaire.

We calculated the effect sizes (difference between means in standard deviations) of a number of key univariate comparisons in order to give a feel for the magnitude of the differences observed (see Table 4). According to Cohen (1992), a medium effect size (an effect likely to be visible to the naked eye of a careful observer) is 0.5, a small effect size is 0.2, and a large effect size is 0.8.

2.3. Discussion

In general, motorcyclists who imagined they were riding their usual motorcycles took greater risks than both the demographically matched car drivers and the second group of motorcyclists who were asked to imagine they were driving their usual car. However, there were no differences between the groups for more general measures of behavioral intentions (sensation-seeking and social motives). Also, there were no group differences in attitudes to riding/driving. These results indicate that motorcyclists do travel faster, pull out into smaller gaps, and overtake more often than car drivers (though they do not intend to drive closer to the vehicle in front). However, this appears to be a characteristic of being on a motorcycle rather than a characteristic of being a motorcyclist. There were no differences between motorcyclists and car drivers in their car driving behavior (save that motorcyclists appeared to pull out into larger gaps than the car drivers for the gap acceptance/overtaking factor). Motorcyclists do not appear to be a unique group of people that differ from the driving population in terms of their general risk-taking behavior.

The motorcyclists in our sample had better hazard perception than the car drivers, which mirrors findings by Underwood and Chapman (1998). However, while this benefit was present when they were imagining they were driving a car, it was absent when they were asked to imagine they were on a motorcycle. The most plausible explanation of these results is that the hazard perception test was originally designed for cars and some of the hazards measured involved fitting through restricted openings in traffic, which arguably represent less of a hazard for a motorcycle. This

Table 3
Group means for the significant effects of group on the laboratory measures (see Table 1), with Student–Newman–Keuls post hoc test results

	Group means: z-scores (standard deviation)		
	Speed/attitudes factor (higher score is more risky behavior)	Overtaking/gap acceptance factor (higher score is more risky behavior)	Hazard perception (higher score is faster reactions)
Group 1: drivers in cars ($n = 48$)	−0.34 (0.78)	−0.14 (0.99)	0.09 (1.05)
Group 2: motorcyclists in cars ($n = 47$)	−0.24 (0.90)	−0.50 (0.74)	0.31 (0.87)
Group 3: motorcyclists on motorcycles ($n = 47$)	0.58 (1.05)	0.65 (0.89)	−0.22 (1.02)
S–N–K post hoc results	Group 3 more risky than groups 1 and 2, $P < 0.05$, which did not differ, $P > 0.05$	All groups significantly different, $P < 0.05$	Group 2 faster than groups 1 and 3, $P < 0.05$, which did not differ, $P > 0.05$

Table 4
Effect sizes (difference between means in standard deviations) of key significant differences in Study 1

Variable	Groups compared	Effect size
Speed/attitude factor	Motorcyclists on motorcycles vs. car drivers in cars	0.92
Gap acceptance/overtaking factor	Motorcyclists on motorcycles vs. car drivers in cars	0.79
Hazard perception	Motorcyclists in cars vs. car drivers in cars	0.40
Speed factor	Motorcyclists on motorcycles vs. car drivers in cars	0.95

would imply that motorcyclists do have better hazard perception than car drivers overall but, to detect differences in hazard perception for motorcyclists on motorcycles, a hazard perception test that specifically tested hazards more relevant to motorcyclists would be required.

3. Study 2

Any particular research method is associated with strengths and weaknesses. For example, while the laboratory-based methods used in Study 1 are highly controlled and yield a high quantity of detailed information, they are one step removed from the real world. One way of avoiding the weaknesses associated with any particular research method is to use more than one method to address the same research question.

In Study 2, we attempted to address the same question as Study 1 (whether motorcyclists behave differently from a matched control group of car drivers) using a field study in which road users were observed unobtrusively from the roadside.

3.1. Method

3.1.1. Sample

Five hundred and sixty observations were made in total. There were 110 motorcyclists (all male) and 450 car drivers (all male), who were matched to the motorcyclists as detailed below. Twenty of the motorcyclists were estimated to be between 17 and 29 years old, 90 were estimated to be between 30 and 55 years old, and none were judged to be over 55. Sixty-one of the car drivers were estimated to be between 17 and 29 years old, 389 were judged to be between 30 and 55 years, with none over 55.

3.1.2. Procedure

Roadside monitoring took place at 5 different sites in the UK (three in Reading, one in Exeter, one in Yeovil), on 22 days between May 2000 and April 2001. Sites were chosen on the following criteria: (1) that the speed gun/video camera could be used without road users being aware of it; (2) that the road had either a 30 or 40 mph limit; (3) that the site was clear of static hazards such as pedestrian crossings.

The speed of all motorcycles that passed was measured if they met the following criteria: (1) their speed was unrestricted by other vehicles in front; (2) the motorcycle was judged to have an engine capacity of at least 125cc (no mopeds); (3) estimation of rider age and gender was possible.

Cars were selected to be matched to each motorcycle observation on the following criteria: (1) the drivers' age was judged to be in the same age range as the motorcyclist (17–29, 30–55, >55 years), (2) the drivers' gender was the same as the motorcyclist, (3) there were the same number of passengers in the car as there were on the motorcycle (in most cases, none), (4) the direction of travel was the same, (5) the site was the same, (6) the time of day was approximately the same (within 2 h), (7) the matched observations were taken on the same day, and (8) the weather conditions were the same.

If the speed gun could not be readied in time, speed was measured using video footage of the vehicles taken with a 3CCD digital video camera positioned to film perpendicular to the road. Work vehicles (e.g. taxis) and drivers or riders under instruction or instructing were excluded from the sample.

3.2. Results

In addition to the procedural matching of motorcyclists and car drivers, we used statistical modeling to control for other influences on speeding behavior. Date, site, driver age (younger versus older), and vehicle type (motorcycle versus car) were entered, in that order, into a general linear model predicting speed using a Type 1 procedure for estimating sum of squares (where each variable is adjusted for the effects of the preceding variable). No interaction terms were included in the model reported. Date accounted for variations in environment that might affect speed such as season, day of week, etc. The site variable was included because on certain dates more than one site was monitored. Motorcyclists were significantly faster than car drivers, after all of these effects were controlled for (see Table 5).

In order to compare the magnitude of the difference in speed between motorcyclists and car drivers with the laboratory measures, we calculated the effect size (difference between the means, measured in population standard deviations, see Cohen, 1992) based on the means predicted by the model. The predicted mean speed of motorcyclists was 43.69 mph (S.D.: 4.93) and for car drivers it was 41.70 mph (S.D.: 4.68). The effect size was 0.42 of a standard deviation between the means.

Table 5
General linear model (Type 1 SOS) predicting speed (no interaction terms included)

Independent variables (in order)	Effect on speed
Date	$F(21, 532) = 13.46$, M.S.E. $= 36.86$, $P < 0.0005$
Site	$F(4, 532) = 4.64$, M.S.E. $= 36.86$, $P = 0.001$
Age (17–29 years vs. 30–55 years)	$F(1, 532) = 22.82$, M.S.E. $= 36.86$, $P < 0.0005$
Vehicle type (motorcycle vs. car)	$F(1, 532) = 23.65$, M.S.E. $= 36.86$, $P < 0.0005$

3.3. Discussion

Automatic speed data (Department of the Environment, Transport, and the Regions, 1999) has found motorcycle speeds to be exactly the same as car speeds, but with a larger variance. Though these data involved a much greater sample size than the present study, motorcyclists were not demographically-matched with car drivers, and the definition of motorcycles included all powered two-wheeled vehicles (i.e. mopeds and other lower powered vehicles were included). This is likely to account for the discrepancy between the two studies.

The data mirrors the results from the laboratory measures of speeding in Study 1, indicating that the finding was robust. However, the effect size was substantially smaller for the roadside data.

4. Study 3

For the reasons outlined in Study 2, we collected roadside data from motorcyclists and a matched group of car drivers for following distance to the vehicle in front. Given we found no significant difference between motorcyclists' and car drivers' following distances for the three laboratory measures used in Study 1 despite reasonable power, we predicted that we would find either a non-significant or a small difference in the present study.

4.1. Method

4.1.1. Sample

Two hundred and seven observations were made. There were 65 motorcyclists and 102 car drivers, who were matched to the motorcyclists as detailed later. There were four females (two motorcyclists and two car drivers) and 213 males. Sixteen of the motorcyclists were estimated to be between 17 and 29 years old, 35 were estimated to be between 30 and 55 years old, and none were judged to be over 55. Forty-nine of the car drivers were estimated to be between 17 and 29 years old, 117 were judged to be between 30 and 55 years, with none over 55. The four females were all in the 17–29-year-old group.

4.1.2. Procedure

We used a similar procedure to Study 2, monitoring traffic at three sites, on 11 separate days between December 2000 and April 2001. The criteria for inclusion were the same as in Study 2, with the exception that vehicles were only sampled if: (1) their progress along the road was judged to be unambiguously limited by the vehicle they were following; (2) the following distance between the two vehicles was judged to have remained constant over the entire viewing distance before the sampling point was reached; and (3) the vehicle being followed was a car. So, as to ensure that our measure of close following was independent of speed, we used the time between the rear of the lead vehicle and the front of the following vehicle as our dependent measure. This was measured using video footage of the vehicles taken with a 3CCD digital video camera positioned perpendicular to the road. Mean following times are reported in milliseconds, although it should be noted that individual observations were measured to the nearest 40 ms. This is because the times were derived from the number of video frames between vehicles (frame length: 40 ms).

4.2. Results and discussion

As in Study 2, we used statistical modeling to match the motorcyclists with the car drivers in addition to the procedural matching. Date, age (17–29 years versus 30–55 years), and vehicle type (motorcycle versus car) were entered, in that order, into a general linear model predicting speed using a Type 1 procedure for estimating the sum of squares (where each variable is adjusted for the effects of the preceding variable). No interaction terms were included. Unlike Study 2, the site variable was not included because it was redundant in the present data set (no more than one site was used on any one date). There was no significant effect of vehicle type on following distance, $F(1, 204) = 1.30$, M.S.E. $= 0.37$, $P = 0.256$.

There was also no significant difference between the following distances of motorcyclists and car drivers without statistical (but with procedural) matching, $t(99.56) = -0.60$, $P = 0.547$ (variances significantly different, so equality of variance not assumed). This was despite there being an 80% chance of detecting an effect size of 0.41 at the 5% level of significance.

This finding confirmed our prediction. The data suggested that there was no significant difference in following distance between car drivers and motorcyclists despite reasonable power, replicating the laboratory findings from Study 1.

5. General discussion

Our findings revealed that motorcyclists do travel faster than a matched group of car drivers, whether measured in the laboratory or by the roadside (though the magnitude of the speed difference from the roadside study was smaller). There does not appear to be any difference between the groups for distance following behind the vehicle in front, despite reasonable power, either when measured in the laboratory or by the roadside. Study 1 also indicated that motorcyclists overtake more often and pull out into smaller gaps in traffic. However, the different behavior of motorcyclists in these contexts does not necessarily lead to a proportional reduction in safety margin, given the different performance characteristics of motorcycles such as greater acceleration.

What proportion of the difference between motorcyclists' and car drivers' accident risk is likely to be accounted for by the differences in accident-related behavior found? While this question is difficult to address directly, we can obtain a feel for the accident risk implications by calculating the extent to which the mean predicted speeds obtained from the model in Study 2 reflect increased fatality risk given an accident, using the rule of thumb equation developed by Joksch (1993). Assuming mean speed choice maps onto impact speed if a crash occurs, then the sample of matched drivers would have a 21% chance of dying given a crash at 41.70 mph. If the motorcyclists crashed a car at their faster speed of 43.69 mph (hence, controlling for physical vulnerability as well as demographics), they would have a 25% chance of dying. That is, in this hypothetical situation, speed alone would only account for a 4% difference in fatality risk between car drivers and motorcyclists. Given that Hurt et al. (1981) found the median pre-crash speed of a sample of 900 motorcycle accidents in the City of Los Angeles to be 29.7 mph (47.5 kph), we might expect the actual contribution of speed to be even smaller than this. This suggests that the large difference between the crash liability and injury severity of motorcyclists and car drivers described in the introduction is unlikely to be accounted for by differences in speeding behavior once demographics and physical vulnerability are controlled for.

A second question of interest was whether motorcyclists represent a qualitatively different group of people from non-motorcycling car drivers or whether the differences in behavior observed were a function of the mode of transport. Our data tended to support the latter explanation. In Study 1, motorcyclists who completed the measures as if they were driving their usual car either did not differ significantly from car drivers (speed and violations) or behaved more safely (overtaking and gap acceptance). Also, motorcyclists and non-motorcycling car drivers did not differ on more general characteristics and attitudes, such as sensation seeking, social motives, and attitudes to driving/riding.

One way in which motorcyclists did perform differently in cars than non-motorcyclists was their ability to detect hazardous situations. Motorcyclists driving cars were significantly faster at detecting hazards than car drivers and we would expect this to reduce their accident risk, given the relationship between hazard perception and accident involvement (McKenna and Horswill, 1999; Quimby et al., 1986).

There is an issue about the generalizability of the findings, given that our sample in Study 1 appeared to travel further per year and was more likely to have advanced training than the average driver. However, the samples in Studies 2 and 3 were more likely to be representative and yet findings with these samples replicated Study 1 results. Also, it should be noted that we were considering larger motorcycles in all three studies and it is plausible that different patterns of results would emerge for specific subsets of the motorcycling population, such as moped or scooter riders.

In summary, we suggest that there are behaviors exhibited by motorcyclists that may increase (speed, gap acceptance, overtaking) or decrease (hazard perception) their accident risk, relative to car drivers. The amount of motorcyclists' accident risk these behaviors can account for is unclear, but our exploratory calculation with speed choice indicates that, relative to other plausible contributory factors (e.g. physical vulnerability and behavior of other road users) and accounting for demographic differences between motorcyclists and car drivers, the influence of motorcyclists' behavior on their accident risk may be surprisingly small.

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