Attending overtaking cars and motorcycles through the mirrors before changing lanes

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1. Introduction

Motorcyclists’ overrepresentation in road fatalities is a well established fact. Right of way violation (ROWV) crashes where another vehicle violates the motorcyclist’s right of way has been identified as the most common type of accident that motorcyclists face (Clarke et al., 2007; Hurt et al., 1981; Wulf et al., 1989). ROWV crashes, typically referred to as Look But Fail To See errors (LBFTS; Brown, 2002) because drivers involved in these accidents frequently report that they failed to notice the conflicting vehicle in spite of looking in the appropriate direction, commonly occur at T-junctions (Clarke et al., 2007; Hole et al., 1996), at crossroads (Clarke et al., 2007; Hurt et al., 1981), roundabouts (Clarke et al., 2007), when drivers change lanes (Clarke et al., 2007) and when they perform u-turns in front of motorcyclists (Sexton et al., 2004). At least in the UK, in most such cases these crashes are primarily the fault of the other road user (Clarke et al., 2007).

ROWV crashes involving motorcycles may be attributed to a wide range of reasons (for reviews, see Crundall et al., 2008b; Wulf et al., 1989). Much of the research has focussed on investigating the physical attributes of motorcycles, and of the riders, that may contribute to enhance salience (e.g., size, spatial frequency, daytime running light, colours). Road users may, for example, have more difficulties in spotting motorcycles (compared to cars) simply because motorcycles are smaller objects.

Due to the (smaller) size of motorcycles, road users may also have greater difficulties in correctly estimating their arrival times. Specifically, the size of an approaching vehicle can influence the perception of its speed and the time it will arrive at the junction (size-arrival effect; DeLucia, 1991; Horswill et al., 2005). This typically leads to overestimation of arrival times for smaller, as compared to larger vehicles, resulting in larger safety margins that drivers tend to apply to large, as compared to small vehicles (for gap acceptance decisions, see also Caird and Hancock, 2007).

Perception of motorcycles is also influenced by top-down factors such as familiarity with motorcycles and expectancy to see them. Typically referred to as cognitive conspicuity (e.g., Hancock et al., 1990), previous experience and expectations of the observer play a significant role in failures to detect unexpected vehicles such as motorcycles. For example, Brooks and Guppy’s (1990) finding
that drivers who have ridden pillion with family members or close friends who ride motorcycles are less likely to collide with motorcycles, and show better observation of motorcycles than other car drivers. This shows that a minimal appreciation of the risk that is posed to family and friends who are motorcyclists is enough to improve ability to spot and avoid motorcycles while driving.

The interaction between bottom-up and top-down factors can induce LBFTS errors and ROWVs by contributing to both failures to detect the conflicting motorcycles and to judge the crash risk that they pose (e.g., time-to-contact). It is possible for example that, from a distance, a short fixation may be enough to identify an approaching car, but not a motorcycle. With the length of gaze typically interpreted as the amount of time devoted to processing a stimulus, longer and shorter gazes reflect difficult and simple processing, respectively. Short gazes on stimuli that should induce reasonably lengthy gazes are likely to reflect a failure to process these stimuli (Rayner et al., 2004; Williams and Pollatsek, 2007). Moreover, motorcycles demand more processing capacity than cars due to their lower salience and greater manoeuvrability which increases the difficulty to predict what they will do next. Based on the above one can expect longer gazes on motorcycles than on cars.

With the most common type of ROWVs involving motorcycles occurring at T-junctions (Clarke et al., 2007; Hole et al., 1996), most research regarding such collisions has naturally chosen to focus on these scenarios (e.g., Horswill et al., 2005; Pal and Saleh, 2008). The present study was concerned about scenarios which require noticing whether there is traffic from behind that is about to overtake. Novice-, experienced- and dual drivers were presented with video clips with mirror information inset and were required to search for the overtaking vehicles in the mirrors and decide when it can be considered safe to change lanes, while their eye movements were being monitored.

Dual drivers were chosen based on evidence that they are likely to have better attitudes towards motorcycles (Crundall et al., 2008a), better hazard perception skills than non-motorcyclist car drivers (Horswill and Helman, 2003; Haworth et al., 2005), and are less likely to crash into other motorcyclists when driving a car (Magazzù et al., 2006). Thus they provide the theoretical gold standard to compare other driver groups against.

Theoretically it made sense to expect that motorcycles would receive more attention than cars because they are less salient, therefore harder to process and require longer processing. If however this is not found (i.e., if the time invested in processing motorcycles is only equal to, or perhaps even less than, the time invested in processing cars, as indicated by total gaze duration), this would suggest motorcycles might be processed to a lesser extent than cars (more salient objects are processed more rapidly than less salient objects). Finally, based on the evidence mentioned above regarding dual drivers, the general expectation was that motorcyclist drivers would allocate more attention to the conflicting motorcycles than the novice and the experienced car drivers.

2. Method

2.1. Participants

Eighty one participants took part in the experiment, and were offered £10 for their time. The data of five female participants were excluded from the novice group to make the male/female ratio of the three groups more similar (those with either the poorest calibration and/or with the largest number of missing trials due to system crashes). One experienced car driver was excluded due to prior motorcycle riding experience. Thus, there were 25 novice car drivers (mean age = 20.6, SD = 2.2; mean license seniority defined as the number of years since the driver had passed the driving test = 1.6, SD = 0.6), 25 experienced car drivers (mean age = 33.4, SD = 8.5; mean license seniority = 14.8, SD = 7.9), and 24 dual drivers (mean age = 44.9, SD = 9.6; mean car license seniority = 25.7, SD = 11.3; mean motorcycle license seniority = 20.0, SD = 11.0). All of the participants reported normal or corrected-to-normal vision.

2.2. Apparatus and stimuli

2.2.1. Filming, editing and clip selection

All footage was filmed around Nottingham, England, using video cameras which were mounted externally to a film car and recorded the front and side views, and the rear views that one would see in the three mirrors. In addition to a series of hazard perception clips, most of the clips that were filmed aimed to allow investigation of hypotheses regarding car-motorcycle interactions at T-junctions or while changing lanes. For the changing lanes scenarios, the film footage included scenarios in which motorcycles and cars would approach the film car from behind (one lane to the right of the film car) and overtake on the off-side. These manoeuvres occurred on multiple-carriageway roads thereby enabling drivers to search for the overtaking vehicles (for more details and discussion on T-junction clips, which were not analysed in the current paper, see Crundall et al., in press). The majority of the clips involved stooge vehicles. A variety of vehicles were used across clips. The footage gathered was edited into clips lasting between 10 and 30 s. The forward views from the three forward facing cameras were synchronized during video editing, and the sources of mirror information were inserted in the forward views. The rear view mirror information was placed at a top central location on the video stream from the central-facing camera, the left mirror stream was placed in the right-hand corner of the video-stream from the camera facing forward and to the left, and the right mirror stream was placed in the left-hand corner of the video-stream that came from the camera facing forward and to the right.

A pilot was then conducted to ensure that all the clips with overtaking vehicles did not allow participants to make a safe response to change lanes until after the conflicting vehicle had passed. Four driving psychologists viewed the clips and rated them as to how safe it would be to make an early manoeuvre between lanes rather than waiting for the conflicting traffic to pass. They had three options to choose from: safe to change lanes without waiting, unsafe to change lanes without waiting and ambiguous. Safe responses scored 1 point, ambiguous responses scored 2 and unsafe decisions scored 3 points. Mean ratings for the change-lane clips ranged from 2.25 to 3 with a mean of 2.85. On this basis, all responses prior to the safe point were considered as risky. ‘Time to Contact’ for the change-lane clips was determined by subtracting the time that the vehicle became visible in the side mirror (equivalent to the start of each clip) from the time at which the front of the conflicting vehicle entered the right side of the right screen (i.e., when the vehicle first became visible in the right screen). There was no significant difference in time to contact between motorcycle clips and car clips (M = 6.80 s, SD = 3.25 vs. M = 6.25 s, SD = 2.48), t(18) = 0.43, p = 0.67.

Thus, for all of the clips included in the experiment, when the clip began there either was a motorcycle or a car already visible in the mirrors (in conflicting vehicle clips), or neither (in no-vehicle clips). In conflicting-vehicle clips, the driver would be expected (based on the pilot) to wait until the vehicle had passed the film-car before it could be considered safe to change lanes. However, when there was no vehicle present, the driver would be fine indicating immediately, after having inspected the mirrors, that it was safe to change lanes. The right screen (see next section) contained the right hand lane, which was the target destination of the participant.
An additional set of 12 hazard perception clips was also selected for presentation in the experiment (not analysed in the current paper). The final playlist used in the experiment consisted of 72 clips, which were played randomly. There were 30 ‘change lanes’ and 30 T-junction clips. For the change lanes condition, in ten of the clips the overtaking vehicle was a car, in ten it was a motorcycle, and in ten there was no overtaking vehicle.

2.2.2. Three screen playback system and experimental set-up

The playback system consisted of a PC workstation and three 40 in. televisions. The central screen displayed the front view while the two further screens positioned to the left and right of the central screen at a set angle of 120° displayed the side views. A push button and a foot-pedal were provided for participants to record their responses obtained to execute a manoeuvre, and their responses to hazards, respectively. A more detailed description of the filming and editing of the clips, and of the playback system and experimental set-up can be found in Shahar et al. (2010). A Smart Eye Pro (Smart Eye®) head and gaze tracking system was used to record eye movements. The system is based on combined pupil and corneal reflection tracking. The setup for recording eye movements consisted of four Sony cameras mounted with 12 mm lenses and positioned above the bottom border of the screens at fixed distances away from each other on the horizontal plane. Using this four camera setup, the system permits a high freedom in head rotation (the setup can be seen in Shahar et al., 2010, Fig. 1). Prior to data collection, for each participant the software (Smart Eye Pro 5.4 was used) builds a unique head model using facial features, following which, a standard gaze calibration procedure was performed.

2.3. Procedure

Participants were seated approximately 115 cm from the central screen. They were told that they would be presented with video clips taken from a car driver’s viewpoint, where the central screen would display the front view from a moving vehicle, while the further screens would display the side views. They also were told that small video streams were positioned across the three screens, in the same arrangement and location that the three mirrors are placed within a car. They were told these ‘mirrors’ would allow them to see information from behind the vehicle. Participants were explained that before each clip began they would hear a voice telling them what the driver intends to do during the clip—either pull out of a T-junction or change lanes to the right (in the UK this means to keep an eye for vehicles that overtake rather than vehicles that undertake) and they were instructed to press a hand-held button as quickly as possible when they thought it was safe to make that particular manoeuvre. Finally, participants were asked to keep an eye out for any hazardous situations, such as where the driver should change his or her driving behaviour to avoid danger (i.e., braking, swerving, etc.).

Participants were instructed to press the foot pedal as quickly as possible to show that they had spotted the hazard. The rationale for the inclusion of the hazard perception task was to maintain a level of uncertainty regarding what might happen. Each clip played until the hand-held button was pressed. The screen then went black for 3 s before the next clip was presented. Button responses were recorded and participants were informed on-screen that they had pressed a button. After the participants had read the instructions, the experimenter started the session.

3. Results

3.1. Button presses to change lanes

On the basis of the pilot, all responses prior to the safe point were considered as risky, and all responses after the safe point were considered cautious. The safe point was defined as the time at which the conflicting vehicle had overtaken the participant’s vehicle to such an extent that the middle of the rear of the vehicle was aligned with the right-most edge of the inset right side mirror (see Fig. 1). Thus the conflicting vehicle was far enough ahead of the participants to allow drivers to decide to initiate the manoeuvre. In spite of this, one might argue that we have chosen a relatively liberal criterion – from a driving safety perspective – to distinguish risky from cautious responses (we have done so in order to avoid categorizing responses executed after the overtaking vehicle had passed together with risky responses obtained while the overtaking vehicle was still a threat). In other words, responses obtained immediately after the overtaking vehicle had passed (see Fig. 1) were considered safe, even though manoeuvres executed at that stage would have probably left too little of a safety gap from the overtaking vehicle. For that reason, even though responses obtained after the safe-point were considered cautious, the speed of these responses could yet provide another measure to distinguish between less and more cautious responses, with faster responses reflecting manoeuvres that leave less of a safe distance from the overtaking vehicle (hence riskier) and vice versa.

One car clip was removed from all of the analyses as very few participants thought there was a safe point at which to pull out. The data of two additional car clips, in which there were two or more cars passing the film car fairly soon after each other with a proportion of the participants pressing to pull out after the first car, and another proportion after the next, were also excluded from this analysis.

In spite of the group differences in age, by partialling out age through ANCOVA we would have breached the statistical conditions under which an ANCOVA should be conducted, due to heterogeneity of the regression slopes of both the within and between-subject factors. A series of $3 \times 2$ (group × vehicle) mixed ANOVAs were performed on the proportion of risky responses and on RTs for cautious responses. Only car and motorcycle were used in these mixed ANOVAs because for the no-vehicle clips there was no differentiation between risky and cautious manoeuvres. The proportion of risky responses was significantly lower when the approaching vehicle was a motorcycle ($M=0.10$, $SD=0.16$) than when it was a car ($M=0.17$, $SD=0.21$), $F(1,71)=12.04$, MSE $= .01$, $p<0.01$. The main effect of group and the interaction were not significant ($F_{S}<.12$, $p$s $>.10$). The ANOVA performed on RTs yielded a group effect, $F(2,71)=4.16$, MSE $=.86$, $p<0.05$. Tukey tests revealed...
that the dual drivers responded faster than the experienced-drivers ($M = 1.20$ s, SD = 0.56 s vs. $M = 1.73$ s, SD = 0.99). The vehicle effect and the interaction were not significant [$F < 1.6$, $p > 0.10$]. A comparison of RTs to the no-vehicle trials across group ($1 \times 3$ between-groups ANOVA) did not show any difference between the groups [$F < 1$, $p > 0.10$].

### 3.2. Eye movement data

Eye locations were categorized during each clip if they fell upon the rear view mirror (RVM), the right side mirror (RSM), or the right screen (RS), which contained the right hand lane (the target destination of the participants), though the central screen was also calculated for purposes of displaying the overall mean gaze durations for the three drivers groups (Fig. 2). Within each category, measures of gaze include the latency to the first fixation, the duration of the first gaze (the total of all fixations within a category from the first time a participant looks at the category to the first time they look somewhere else), the mean gaze duration, and the total proportion of time that drivers spent looking at that area. Fig. 2 displays mean gaze durations on the mirrors and on the right and front screens, for the three drivers groups.

Before comparing gaze measures across the groups, a series of 2 way ANOVAs were undertaken to assess whether the motorcycle and car clips differed systematically in the amount of time that the target vehicle (or any other vehicle) was visible in any of the areas of interest. The results did not show any differences, suggesting that the clips are comparable [$F_s < 1.7$, $p_s > .10$]. A series of $3 \times 3$ (experience x vehicle) mixed ANOVAs were performed on each of the dependent measures. Simple contrasts were used to compare driver groups (novices to duals, and experienced to duals) while Helmert contrasts were used for the vehicle trials (comparing no-vehicle trials to the average of car and motorcycle trials, and also directly comparing car- to motorcycle-trials).

#### 3.2.1. Rear view mirror

The analysis of the latencies to the first fixation yielded a vehicle effect ($F(2,142) = 11.4$, $MSe = 1.0$, $p < 0.001$). Participants looked more quickly at the RVM in the no-vehicle clips ($M = 1.0$ s) compared to the vehicle clips ($F(1,71) = 30.5$, $MSe = 1.1$, $p < 0.001$) though the difference between motorcycle ($M = 1.6$ s) and car ($M = 1.8$ s) clips was not significant. An a priori contrast comparing experienced- with dual drivers provided marginal evidence for a difference, with experienced drivers fixing the RVM on average 1.0 s after the start of the clip compared to the 1.6 s of dual drivers and 1.7 s of novices.

![Fig. 2. Mean gaze durations on the (rear-view and right-side) mirrors and on the right and front screens, for the novice, experienced and dual drivers. Error bars represent standard error of means.](image)

Analysis of the first gaze duration also revealed a significant vehicle effect ($F(2,142) = 67$, $MSe = 37,062$, $p < 0.001$), with the no-vehicle trials ($M = 405$ ms) producing the shortest first gaze on the RVM compared to the vehicle trials, and motorcycle clips ($M = 769$ ms) inducing longer first gaze durations on the RVM than car clips ($M = 626$ ms; $F(1,71) > 21$, $MSe = 58,091$, $p < 0.001$). The a priori interaction contrasts also suggested an interaction ($F(2,71) = 3.1$, $MSe = 70,793$, $p = 0.05$; even though the omnibus interaction only approached significance levels; $p = 0.098$), suggesting that dual drivers had longer first gazes on the RVM in the motorcycle clips compared to the other two groups.

The analysis of the mean gaze duration also revealed a vehicle effect ($F(2,142) = 82.2$, $MSe = 16,613$, $p < 0.001$) which is explained by a significant interaction ($F(4,142) = 2.5$, $MSe = 16,614$, $p < 0.05$) that was again due to longer gazes by the dual drivers on the motorcycle clips (see Fig. 3). To further explore whether this interaction was dependent on the data of the first gaze, these data were omitted: the interaction was no longer significant [$F = 1$, $p > 0.10$], though it should be noted that the fact that in the analysis of the first gaze the omnibus interaction was not significant, whereas the interaction was significant with mean gaze duration, suggests the latter effect is not totally dependent of the former. The ANOVA which excluded the first gaze did yield however a vehicle effect, $F(2,110) = 57.96$, $MSe = 17,010.92$, $p < 0.001$, indicating longer mean gaze durations on the mirror when there was a car ($M = 532$ ms, SD = 160) than without a vehicle ($M = 359$, SD = 150 ms), and the mean gaze durations were even longer when there was a motorcycle ($M = 608$ ms, SD = 177 ms; $F(1,55) = 48.45$ and 15.12, respectively, $p < .001$). The group effect was also significant, $F(1,55) = 3.63$, $p < 0.05$. Tukey tests showed that the dual drivers ($M = 553$ ms, SD = 111 ms) had significantly longer gaze durations than the experienced car drivers ($M = 452$ ms, SD = 85 ms), whereas the differences between the novices ($M = 502$, SD = 145 ms) and the two other groups were not significant ($p > .10$).

Finally no-vehicle clips (21%) resulted in the smallest percentage of attention being devoted to the RVM compared to the combined motorcycle and car clips ($F(1,71) = 14.2$, $MSe = 70$, $p < 0.001$), while the motorcycle clips (26%) garnered a greater portion of attention than the car clips (23%) ($F(1,71) = 17.5$, $MSe = 45$, $p < 0.001$).

#### 3.2.2. Right side mirror

The analysis of the latencies to first fixate on the RSM revealed an effect of vehicle ($F(2,142) = 32.07$, $MSe = 0.96$, $p < 0.001$), with conflicting traffic trials producing later gazes than the no-vehicle trials ($F(1,71) = 47.5$, $MSe = 1.9$, $p < 0.001$). This effect is further moderated by an experience x vehicle interaction ($F(4,142) = 2.6$, $MSe = 0.96$, $p < 0.05$). The contrasts suggest that the effect lies in the comparison of no-vehicle trials to the combined conflicting vehicle trials ($F(1,71) = 3.0$, $MSe = 1.9$, $p = 0.055$). The experienced drivers
appeared to have delayed their fixation on the RSM to the greatest extent in the presence of a conflicting vehicle (as compared to the no-vehicle trials, the vehicle clips produced between 0.5 and 1 s average delay for both novices and dual drivers, but they produced a 1.5 s delay for the experienced drivers).

The analysis of the duration of the first gaze revealed effects of both vehicle \(F(2,142) = 22.96,\) MSe = 43,728, \(p < 0.001\) and experience \(F(1,71) = 4.9,\) MSe = 62,449, \(p < 0.01\) but no interaction. No-vehicle trials produced the shortest gazes compared to the conflicting vehicle trials \(F(1,71) = 34.5,\) MSe = 69,408, \(p < 0.001\), and motorcycle clips received longer gazes than car clips \(F(1,71) = 5.5,\) MSe = 82,368, \(p < 0.05\). Simple contrasts revealed that the experienced drivers had shorter average first gazes than dual drivers \((388\, \text{ms}\, \text{vs.}\, 572\, \text{ms};\, p < 0.05)\), while novice drivers were similar to the dual drivers \((589\, \text{ms})\).

The analysis of the mean gaze duration revealed significant effects of vehicle \(F(2,142) = 20.66,\) MSe = 14,445, \(p < 0.001\) and of experience \(F(1,71) = 4.42,\) MSe = 178,211, \(p < 0.05\) but no interaction \(F = 2.48;\, p = 0.10\). Similarly to the first gaze durations, experienced drivers also had a shorter mean gaze duration than dual drivers \((315\, \text{ms}\, \text{vs.}\, 451\, \text{ms})\) while novices were more similar to the dual drivers \((474\, \text{ms})\) and no-vehicle trials produced the shortest mean gazes on the RSM \((F(1,71) = 28.5,\) MSe = 29,461, \(p < 0.001\)). In addition, motorcycle clips evoked longer mean gazes on the RSM than car clips \((F(1,71) = 3.9,\) MSe = 18,500, \(p < 0.05)\).

The analysis of the percentage of time participants spent looking at the RSM revealed a significant effect of vehicle \(F(2,142) = 2.99,\) MSe = 34.06, \(p < 0.05\), but the effect of experience and the interaction were not significant. Contrasts suggested that the RSM on motorcycle clips received a small but significantly greater proportion of the total gaze durations than the car clips \((24.1\% \text{ vs.} 21.8\%;\, F(1,71) = 8.8,\) MSe = 45, \(p < 0.005)\).

### 3.2.3. Right screen

For all measures, only the factor of vehicle was significant. Participants were quickest to fixate the RS in the no-vehicle trials and slowest in the motorcycle trials \(F(2,142) = 53,\) MSe = 2.2, \(p < 0.001\), with no-vehicle trials slower than vehicle trials, and motorcycle trials slower than car trials, \(p < 0.001\). To ensure that the slower gaze into the RS for motorcycle clips compared to car clips was not caused by a systematic bias in the clips where cars might be travelling faster than motorcycles, the exposure times of cars and motorcycles from the start of the clip up to the safe point were compared. There was no evidence of a systematic variation favouring one vehicle over the other \(t(18) = 0.43;\, p = 0.67\).

No-vehicle clips produced shorter first- and mean-gazes on the RS than vehicle clips. Mean gaze durations to the RS also revealed shorter average fixations for car clips \((241\, \text{ms})\) compared to motorcycle clips \((306\, \text{ms};\, F(1,71) = 17.7,\) MSe = 12,695, \(p < 0.001)\), and shorter yet in the absence of a conflicting vehicle \((110\, \text{ms})\). The percentage of total gaze followed the same pattern, with a main effect of vehicle \((F(1,71) = 14.2,\) MSe = 70, \(p < 0.001)\), and contrasts suggesting that the RS received the least attention in the no-vehicle trials \((7.3\%\) compared to the conflicting vehicle trials \((F(1,71) = 41,\) MSe = 47, \(p = 0.001),\) within which motorcycle clips accrued a greater proportion of attention than car clips \((14.6\%\, \text{vs.}\, 10.4\%;\, F(1,71) = 57,\) MSe = 23, \(p < 0.001)\).

### 3.3. Correlations between measures of visual search and percentages of safe manoeuvres

The correlations between percentages of safe manoeuvres with conflicting cars and durations of first fixations in the RSM in no-vehicle clips \((r = -0.26)\), and between percentages of safe manoeuvres with conflicting motorcycles and durations of first fixations in the RVM in no-vehicle clips \((r = -0.23)\) were both significant \((p < 0.05)\).

Significant correlations were also found between percentages of safe manoeuvres in car clips and mean gaze durations, in both the RVM \((r = -0.23;\, p < 0.05)\) and RSM \((r = -0.25;\, p < 0.05)\) in no-vehicle clips. Finally, significant correlations were found between percentages of safe manoeuvres in motorcycle clips and mean gaze durations in the RVM in no-vehicle clips \((r = -0.26;\, p < 0.05)\), in car clips \((r = -0.25;\, p < 0.05)\) and in motorcycle clips \((r = -0.28;\, p < 0.05)\).

### 4. Discussion

This study presented clips that allowed participants to check those areas of the visual scene where conflicting traffic would appear in change-lane scenarios. The results have identified differences between groups and conditions, in the eye movement data, in decision-making to make a manoeuvre, and in the speed of such decisions. A greater proportion of cautious responses were made to motorcycles than to cars. Although we do not suggest that such safe behaviour does not reflect decisions made during actual driving, it is likely that this behaviour was also driven by participants’ realization that they were taking part in a driving experiment, and presumably their desire to appear as safe drivers, responding more cautiously to more vulnerable road users. Moreover, the more cautious responses to motorcycles might have reflected the non-realistic high probability of appearance of the motorcycles in the experiment as compared to real traffic conditions.

Once the overtaking vehicle had passed however driving experience influenced the speed in which drivers pressed to change lanes, with dual drivers responding faster than the experienced drivers. While this effect might suggest that dual drivers maintain less distance from the vehicle in front, it should be noted that this behaviour was induced by the experiment’s instructions (to press the button as soon as possible when it is safe to do so) and conditions (participants were required to press before the clips terminated—soon after the safe point). Importantly, this finding also argues against the suggestion that what we have interpreted as more cautious response criteria amongst dual drivers in fact reflects age-related slowing of response times.

In Section 1 it was mentioned that relatively short gazes on stimuli that should induce reasonably lengthy gazes, are likely to reflect a failure to process these stimuli. We also argued that motorcycles should be harder to process than cars, because motorcycles are less salient and have greater manoeuvrability than cars. Based on this rationale we suggested that longer gaze durations should be given to conflicting motorcycles than to conflicting cars. This was indeed the case for both of the mirrors as well as for the right screen. With the mirrors however the patterns of the interaction suggest that these differences between duration lengths for the two types of vehicles were driven by the dual drivers group. While past research has shown that driving experience reduces fixation and gaze durations due to the increment of processing speed and efficiency with experience (e.g., Chapman and Underwood, 1998), one would nonetheless expect experienced and novice drivers to have longer gazes on more complex and less salient objects (i.e., motorcycles). Due to varying levels of inexperience in processing motorcycles (amongst the three groups tested dual drivers do not doubt have the greatest exposure to motorcycles) one would also expect experienced drivers to have longer, or at least equal, gazes on motorcycles compared to dual drivers, and novices to have the longest gazes. We argue that the longer gazes on motorcycles than on cars found in the dual drivers group reflect more appropriate levels of processing in those drivers.

It should be noted that while we assume that this advantage in the dual drivers group is due to the specific motorcycle experience of these drivers, those drivers also have the most car driving experience. If however their additional car driving experience was the
primary contributor to the superior behaviour of the dual drivers, we might expect improvement across the three groups of experience. There was no such indication of a linear improvement with car driving experience. In fact the data from the T-junction clips has not only indicated that the dual drivers were the most sensitive to the presence of a conflicting motorcycle, but also that experienced drivers were the least sensitive (even compared to novices; see Crundall et al., in press). This suggests that greater car driving experience on its own is likely to lead to decreased expectancies for motorcycles and it further argues against any systematic age bias. Nonetheless, based on the age differences between the dual drivers and experienced drivers in this study, future research must try to better differentiate between the contributions that motorcycle riding experience surely has, and that driving experience might have, to the processing of conflicting motorcycles. Finally, although the possibility that the increased processing of motorcycles amongst dual drivers reflects their greater interest in motorcycles cannot be ruled out, the extra caution that dual drivers also showed by glancing for longer durations at the right mirror (across vehicle type) and in T-junction clips in the absence of conflicting motorcycles (see Crundall et al., in press) argues against this as the predominant factor in the increased safety of this group.

Across the vehicle conditions, participants inspected the different areas in the same order: starting by looking ahead, then looking to the RVM, then to the RSM and finally to the right-hand lane (right screen). The only exception occurred with novice drivers who in the car clips looked at the RSM before looking in the RVM.

The first gaze on the RVM was delayed if a conflicting vehicle was available in the mirrors, suggesting that the delayed gaze to the mirror was based on peripheral information. Detection of forms and identification of movement in the mirrors (when conflicting vehicles are present) through peripheral vision, might have encouraged the drivers to spend longer focusing on the forward view before moving to inspect the mirrors.

As compared to experienced drivers, dual drivers tended to look later at the RVM, but then earlier at the RSM, and yet dual drivers had longer first- and longer mean-gazes on the RVM in the motorcycle clips (and across vehicle type as indicated by the analysis that excluded the first gaze data). Thus, experienced drivers might have looked at the RVM first, but most likely returned to the forward view more frequently than the dual drivers.

Experienced drivers made less use of the RSM than the novices and dual drivers, while novices used the mirrors about as much as dual drivers did. Novices’ relatively long gazes on the mirrors may reflect either retention of strategies recently learned during formal driving instruction, or capacity limitations due to inexperience (or possibly a mixture of the two). As a result of the absence of a central RVM on a motorcycle, motorcyclists are obviously much more dependent on the side mirrors. In this study, they have appeared to adopt this strategy of inspection to an experimental setting that simulates a car driver’s perspective. The additional use that the dual drivers make of the RSM however was not at the expense of the RVM and actually there were data to suggest the dual drivers made more use than experienced drivers of the RVM as well.

In summary, experienced drivers made the least use of the mirrors. As compared to the dual drivers who concentrated their time into longer gazes, the experienced drivers favoured a higher sampling rate (switching more frequently between the areas of interest). Longer gazes on motorcycles than on cars were found but were driven from the dual drivers group reflecting more appropriate levels of processing in those drivers.

In conclusion, driving and riding experience appear to influence how drivers attend visual information from behind the vehicle in general, and how they deal with conflicting motorcycles in particular. Specifically, the fact that in the current study non-motorcyclist drivers did not spend more resources to process conflicting motorcycles than cars, whereas dual drivers did, provides indirect support that non-motorcyclists drivers are more likely to have LBFTS errors with conflicting motorcycles than dual drivers. It also suggests that only for non-motorcyclist drivers (but not for dual drivers), LBFTS errors are more likely to occur with motorcycles than with cars. Dual drivers compensate for the reduction in saliency by investing more time in processing these less salient road users. More specifically, the superior performance of the dual drivers group in this study is supported by the fact that (a) a greater proportion of cautious responses were made to motorcycles than to cars, (b) motorcycles also received more attention than cars (as indicated by the eye data), and (c), the amount of overall attention devoted to motorcycles by the participants was predominantly due to the performance of the dual drivers. Finally, this study provides direct evidence (the significant positive correlations that were found between percentages of safe manoeuvres and the measures of visual search) demonstrating that the frequency of risky manoeuvres was indeed larger in those cases where less time was spent gazing at the mirrors. While this clearly indicates that the additional attention devoted to process conflicting vehicles contributes to reduce risky manoeuvres, it is up to future research to further identify below which given thresholds, glances are associated with an increase in LBFTS errors.

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References


