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# A different perspective on conspicuity related motorcycle crashes

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ABSTRACT

The most common type of conflict in which a motorcyclist is injured or killed is a collision between a motorcycle and a car, often in priority situations. Many studies on motorcycle safety focus on the question why car drivers fail to give priority and on the poor conspicuity of motorcycles. The concept of 'looked-but-failed-to-see' crashes is a recurring item. On the other hand, it is not entirely unexpected that motorcycles have many conflicts with cars; there simply are so many cars on the road. This paper tries to unravel whether – acknowledging the differences in exposure – car drivers indeed fail to yield for motorcycles more often than for other cars. For this purpose we compared the causes of crashes on intersections (e.g. failing to give priority, speeding, etc.) between different crash types (car–motorcycle or car–car). In addition, we compared the crash causes of dual drivers (i.e. car drivers who also have their motorcycle licence) with regular car drivers.Our crash analysis suggests that car drivers do not fail to give priority to motorcycles relatively more often than to another car when this car/motorcycle approaches from a perpendicular angle. There is only one priority situation where motorcycles seem to be at a disadvantage compared to cars. This is when a car makes a left turn, and fails to give priority to an oncoming motorcycle. This specific crash scenario occurs more often when the oncoming vehicle is a motorcycle than when it is a car. We did not find a significant difference between dual drivers and regular car drivers in how often they give priority to motorcycles compared to cars.



## 1. Introduction

Motorcycles are vulnerable in traffic. In comparison with drivers of motorised four-wheeled vehicles, a motorcyclist has a high risk of death or serious injury as a result of a crash (SWOV, 2010). The main type of conflict in which a motorcyclist is injured or killed is a collision between a motorcycle and a car or van. In the Netherlands this is the case in around 50% of the crashes (SWOV, 2010). The second most frequent conflict type (almost 40% of motorcycle casualties in the Netherlands) is a single vehicle crash (i.e. not involving another party). Not only in the Netherlands, but also in other countries, many car–motorcycle crashes are caused by the car driver failing to give priority to the motorcyclist (e.g. Pai, 2011). According to a European in-depth study this is mainly because the car driver fails to notice the motorcyclist (MAIDS, 2004, 2009). In traffic literature these types of crashes have become known as "looked-but-failed-to-see" crashes, or "motorcycle conspicuity related" crashes, because they are thought to be related to the lacking conspicuity of motorcycles (Clabaux et al., 2012; Helman et al., 2012; Mitsopoulos-Rubens and Lenné, 2012).

There is extensive research on factors contributing to motorcycle conspicuity related crashes. Crash analysis show, for example, that motorcyclists wearing fluorescent or reflective clothing, or a white or light helmet, have a reduced risk of motorcycle crashes (Wells et al., 2004). Even more important than wearing bright clothing seems to be contrast with the environment (Hole et al., 1996; Rogé et al., 2010; Gershon et al., 2012). For instance, Hole and colleagues found that in urban environments observers responded quicker to motorcyclists with bright coloured or fluorescent clothing than to motorcyclists with dark clothing. This effect was reversed in rural settings (with clear blue sky), where observers responded quicker to motorcyclists wearing dark clothing. Contrast with the environments seems to be an important factor in the effectiveness of daytime running lights (DRL) as well. In general DRL enhances the conspicuity of motorcycles during daytime (e.g. Thomson, 1980; Torrez, 2008). Most studies report this effect to be dependent on the specific situation, such as the characteristics of the environment (Hole and Tyrrell, 1995; Hole et al., 1996), the motorcycle's speed (Howells et al., 1980 as cited in Pai, 2011), or the weather conditions (Pai, 2011).

A motorcycle is smaller than a car, especially the front view. Furthermore, since the size and shape of motorcycles vary a lot, a motorcycle gives less reliable information about its speed and distance than a car. This can explain why depth, distance

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and speed are not as easily derived from a moving motorcycle than from a moving car. Horswill et al. (2005) found that car drivers accept smaller gaps when crossing a road in front of a motorcycle compared to a car. They explain this result with the size-arrival effect that was described by Delucia (1991), which states that smaller objects are perceived to arrive later than larger objects.

In addition to motorcycle characteristics explaining conspicuity related crashes, the expectancy of car drivers for motorcyclists is also often mentioned as an important factor. The human capacity for information processing is limited; humans cannot process all information they are presented with (O'Donnell and Eggemeier, 1986; Coren et al., 1994; Wolfe, 1998). Attention helps people to filter which information they process and which information they do not process (Simons and Chabris, 1999; Mortier et al., 2003; Martens, 2011); expectations in turn help to direct attention (Martens, 2000). So, the theory suggests that car drivers do not expect to encounter motorcycles on the road, and therefore, have more problems perceiving them. Gershon et al. (2012) confirmed the importance of expectancy for the perception of powered two-wheelers. Results of their experiment indicated that when observers were instructed to look for powered two-wheelers in photographs, detection rates were three times higher than without instruction.

A final concept in relation to conspicuity related questions is the suggestion that car drivers have no "awareness and acceptance" for motorcycles (e.g. Crundall et al., 2008). In contrast with expectancy discussed in the previous section this factor has a sort of 'motivational' aspect. Several studies describe that car drivers have negative attitudes towards motorcycle riders (e.g. Savolainen and Mannering, 2007; Crundall et al., 2010; Musselwhite et al., 2012). There is however no evidence that negative attitudes affect car drivers' behaviour and can be related to car–motorcycle crashes. Although many studies report findings by Brooks and Guppy (1990), that drivers with family members or close friends who ride motorcycles are less likely to cause a crash with a motorcyclist, it is important to realise that the original study did not find the reported effect. There is, however, evidence that car drivers who also have their motorcycle licence (so-called dual drivers) are less likely to collide with motorcycles than car drivers without a motorcycle licence (Brooks and Guppy, 1990; Magazzù et al., 2006). But these results can also be explained by dual riders having more technical knowledge about riding a motorcycle, higher expectancy for motorcycles in traffic, and/or more driving/riding experience in general.

The vast amount of literature on conspicuity related crashes is based on the assumption that this is a typical car–motorcycle interaction problem. However, it is not entirely unexpected that motorcycles have many conflicts with cars; there simply are so many cars on the road. This paper aims to answer: (1) if – acknowledging the differences in exposure – it is indeed true that car drivers more often fail to yield to motorcycles than to cars; and (2) whether dual-drivers (i.e. car drivers who also have their motorcycle licence) have fewer problems in their interaction with motorcycles? Especially the first question has not been answered in previous research; probably because it is difficult (or impossible) to correct for differences in exposure between the two vehicle types. For example in the Netherlands, there is some information about the average distance travelled by motorcycle or car. But these estimates are not reliable enough to use as a correction for exposure. In this paper the problem of differences in exposure was circumvented by comparing *relative* crash causes (e.g. failing to give priority, speeding, etc.) on intersections between two different crash types: car–motorcycle or car–car. In addition, we compare the crash cause of dual drivers with that of regular car drivers.

## 2. Method

The analyses in this paper are based on police *registered* crashes with at least a serious injury[1] in the period 2000–2009 in The Netherlands, i.e. the Dutch Road Crash Registration (BRON). The severity of a crash is defined by the most serious injury of one of the persons involved, so a serious injury crash is a crash with at least one victim being seriously injured[2]. There are a number of considerations with the Dutch Road Crash Registration, which are discussed in the next section: (1) crash registration rate, (2) determination of first and second collider, and (3) determination of crash causes.

### 2.1. Limitations of available data

It is important to realise that the number of reported crashes, is not the same as the actual number of crashes (or casualties). For all kind of (practical) reasons the police does not register all crashes and casualties. It is estimated that for fatalities, the registration rate in BRON is still over 90% whereas for serious road injuries among motorcyclists, the registration rate in BRON dropped from about 60% in 2000 to 35% in 2009. In other words, in 2009 the majority of serious injured motorcyclists were not registered in BRON. For more information on Dutch crash registration and registration rates see (SWOV, 2013). For the crash analyses in this report it was not possible to use the estimated ('real') number of serious crashes, because we needed detailed crash information. Therefore we had to resort to the BRON database itself, with imperfect registration. However, because only the relative occurrence of different crash types on intersections are compared, this analysis is most likely not influenced by a lower registration rate.

The analyses use information about the first and second collider in a crash, as available from the BRON registration. The first collider is, according to the *police*, probably the one who caused the crash. It is extremely important to realise that this is the opinion of the policeman who dealt with the crash and recorded it. This does not always have to be the actual causer of the crash. It is possible that, after more research the (legal) responsibility is changed to the other crash partner. However, this is not changed in the registration of the first and second collider in the police records.

Related to the first and second collider issue, there is the issue of the recorded crash cause, which is also the opinion of the policeman recording the crash. Although we know that most crashes have more than one cause, the cause registered in BRON is the cause that is reported for the first collider. There is a tendency to report certain crash causes over others, especially those that are more judicial oriented (i.e. that can be proven more easily). As mentioned before, we only study *relative* occurrence of crash causes for certain conflict types, i.e. we compare the relative occurrence of failing to give way within motorcycle–car crashes with the occurrence of the cause within car–car crashes. Therefore we assume that the preference for a certain causation type does not influence the conclusions of our analysis.

### 2.2. Analysis

We analysed crashes on *intersections* in which someone was killed or seriously injured in the period 2000–2009. The police records describe several different crash causes, such as red light

[1] With the exception of Table 2 where more data was needed and crashes with slight injuries or property damage only were included as well.

[2] The injury severity, Maximum Abbreviated Index Scale (MAIS), was used to identify serious injuries. A serious injury is defined as an injury with at least a MAIS 2 score.

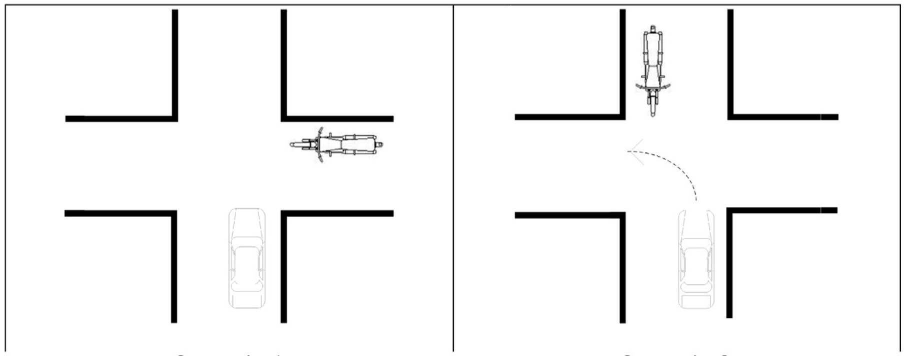


**Fig. 1.** Typical crash scenarios where the car driver fails to give priority (scenario 1) or to give way (scenario 2) to a motorcycle. NB: the motorcycle has priority in all situations.

running, speeding, cutting off, etcetera. There are two types of priority crash causes: that is (1) failing to give *priority*, and (2) failing to give *way*. The first priority crash cause describes the situation where the motorcycle approaches an intersection and has priority (because he/she approaches from the right, or drives on a priority road), but the car driver fails to give priority (see Fig. 1 for an example of this scenario 1). Failing to give way describes a situation where a car driver is making a manoeuvre (taking a left turn) and fails to give way to traffic approaching on the same road (see Fig. 1 scenario 2). The scenarios depicted in Fig. 1 are examples of the most standard occurrence of these two crash causes; in reality there are more scenarios in which a driver can fail to give priority or to give way (i.e. the situation of a priority road). It is important to realise that in scenario 1 the car and motorcycle are approaching the intersection from different roads (at a different angle) and in scenario 2 they are on the same road (and the car driver makes a left turn). In all situations the motorcycle has priority or right of way.

This analysis focuses on a comparison of the relative occurrence of failing to give priority and failing to give way within car–motorcycle crashes and within car–car crashes.

## 3. Results

### 3.1. Crash causes on intersections

A total of 9076 relevant crashes were identified in the crash statistics of 2000–2009. Table 1 shows the causes of four types of crashes on intersections: motorcyclist–motorcyclist (MC → MC; $n = 46$), motorcyclist–car driver (MC → CD; $n = 359$), car driver–motorcyclist (CD → MC; $n = 1259$) and car driver–car driver (CD → CD; $n = 7412$). The first road user mentioned was registered as the first collider and thus considered (legally) responsible for the crash. For each type of crash different crash causes are identified. Because there are much more cars in traffic, Table 1 shows the absolute number as well as the *proportion* of each registered crash cause. So, for example, the first column indicates that in BRON registered crashes with two motorcycles (MC → MC), in 9% of the crashes the motorcycle failed to give priority (scenario 1), in 9% the motorcycle failed to give way (scenario 2), in 67% the motorcycle kept insufficient distance, etcetera. So, the majority of motorcycle–motorcycle crashes reported in BRON are registered by the police as being caused by insufficient distance.

Before discussing the results in the context of motorcycle conspicuity, there are some crash causes in Table 1 that need some further explanation. For example, it is remarkable that speeding is recorded as a cause in so few crashes; especially since we know that speed is one of the basic risk factors in traffic (Aarts and van Schagen, 2006). This can be explained by what was already mentioned in Section 2.3: not all crash causes are equally likely to be recorded as the main crash cause. As speeding cannot be proven easily, this could explain why speeding 'in itself' is relatively rarely recorded as the main crash cause. A second noticeable crash cause is insufficient distance in crashes with two or more motorcycles (in 31 of the 46 motorcycle–motorcycle crashes). These are most likely crashes in which motorcyclists were riding in groups[3]. Because motorcyclists ride in groups relatively often, these types of crashes also occur relatively often. Finally, note that red light running is in fact also an aspect of failing to give priority. This is, however, coded as a separate crash cause by the Dutch police. These crashes are less relevant for the conspicuity of motorcycles topic, and will not be analysed in this paper.

For the purpose of this paper the last four columns and the first two rows of Table 1 are most interesting, i.e. those that describe the priority-related crashes between a motorcycle and a car. This involves a total of 3366 crashes, i.e. 37% of the total number of intersection crashes. When the car driver is registered as the first collider (CD → MC), in 56% of the cases failure to give priority (scenario 1) is the cause of a crash with a motorcycle. The proportion is similar in car–car crashes (CD → CD). This similarity indicates that for car drivers failing to give priority (scenario 1) is not more frequent when the opponent is a motorcycle than when the opponent is a car. However, for scenario 2 there is a difference between car–motorcycle crashes and car–car crashes. When the oncoming vehicle is another car, failing to give way was the primary cause in 13% of the crashes; when the oncoming vehicle was a motorcycle, this was the case in 32% of the cases. This suggests that car drivers have relatively more problems with giving way to a motorcycle than to another car in scenario 2. A chi-square analysis of a cross-tabulation of the two priority scenarios vs. car–motorcycle and car–car crashes (the dark lined square in Table 1) indicates that this difference is significant ($\chi^2(1, N = 3366) = 117.82$, $p < .001$).

### 3.2. Difference between dual drivers and regular car drivers

Table 2 shows the numbers and percentage of failing to give way and failing to give priority for dual drivers (i.e. car drivers who also have their motorcycle licence) and regular car drivers (i.e. car drivers without a motorcycle licence). In contrast with Table 1, Table 2 includes crashes with slightly injured or property damage only. This was necessary since information on driver licence is available only for the period 2006–2009; and without slightly injured or property damage the numbers would be too low for meaningful comparisons.

[3] As understood from personal communication with motorcycle interest groups.

**Table 1**
In BRON registered number and proportion of primary crash causes in crashes on intersections with fatalities and/or serious road injuries over the period 2000–2009.

| | MC → MC | | MC → CD | | CD → MC | | CD → CD | |
|---|---|---|---|---|---|---|---|---|
| | *N* | % | *N* | % | *N* | % | *N* | % |
| Fail to give priority (scenario 1) | 4 | 9 | 89 | 24 | 657 | 56 | 1898 | 56 |
| Fail to give way (scenario 2) | 4 | 9 | 17 | 5 | 372 | 32 | 439 | 13 |
| Insufficient distance | 31 | 67 | 63 | 17 | 18 | 2 | 321 | 9 |
| Cutting off | 2 | 4 | 69 | 19 | 16 | 1 | 47 | 1 |
| Red light running | 0 | 0 | 28 | 8 | 56 | 5 | 406 | 12 |
| Speeding | 0 | 0 | 8 | 2 | 0 | 0 | 13 | 0 |
| Other | 5 | 11 | 98 | 26 | 51 | 4 | 277 | 8 |
| Total number of crashes | 46 | 100 | 359 | 100 | 1259 | 100 | 7412 | 100 |

A total of 2581 relevant crashes were identified, 85 of which involved a dual driver. Table 2 shows that dual drivers have relatively the same amount of failures in giving priority as regular car drivers (resp. 47% and 50% of the crash causes). However, dual drivers do cause less crashes (16%) due to failure to give way on the same road, compared to regular drivers (26%). A Chi-square analysis indicated that this difference between dual drivers and regular car drivers is not significant.

## 4. Discussion

In absolute numbers, the majority of motorcycle crashes are crashes in which a car is involved. The vast amount of literature on conspicuity-related crashes is based on the assumption that this is a typical car–motorcycle interaction problem. However, it is not entirely unexpected that motorcycles have many conflicts with cars; there simply are so many cars on the road. This paper aims to answer: (1) if – acknowledging the differences in – exposure, it is indeed true that car drivers more often fail to yield to motorcycles than to cars; and (2) whether dual-drivers (i.e. car drivers who also have their motorcycle licence) have fewer problems in their interaction with motorcycles.

Concerning research question 1, the comparison of different crash causes on intersections indicate that there is a difference between two priority situations. Failure to give priority (i.e. when the opponent of a car driver is approaching the intersection from a perpendicular angle; scenario 1 in Fig. 1) is the cause in about 56% of the cases, both when the opponent is a car and when it is a motorcycle. This indicates that when car drivers fail to give priority, it seems not to differ much if the other collider is a car or a motorcycle. However, there is a difference for failing to give way (scenario 2 in Fig. 1) between car–motorcycle and car–car crashes. When the oncoming vehicle is another car (car–car crash), failing to give way was registered as the primary crash cause relatively less often (13%) than when the oncoming vehicle was a motorcycle (car–motorcycle crash; 32%). Concerning research question 2, we did not find a significant difference between dual drivers and regular car drivers.

These results may have important consequences for motorcycle-conspicuity research. However, we do need to highlight some shortcomings of our analysis because of data limitations. This analysis could only be performed on registered number of crashes. However, as mentioned in Section 2.1, the registration rate as well as the quality of the registered data is limited. The registration rate for serious road injuries among motorcyclists in 2009 is only about 35%. So, for almost two thirds of the motorcycle victims no information is available. On the other hand, the registration rate for fatalities is much higher than for serious road injuries. Considering that motorcycle crashes are generally more severe, it is possible that they are recorded more often than comparable car crashes. So, a different ratio in type of victims in different conflict types can influence the results. Furthermore, all data are based on the opinion of individual police officers. This especially plays a role in the identification of the main cause for a crash, but also in the registration of first and second collider. In theory, the first collider is the one who caused the crash but that is not always easy to decide. Finally, as mentioned in Section 2.2, the scenarios in Fig. 1 are examples of the most standard occurrence of these two crash causes. We have no information in the crash data on the specific layout of the intersection. In all, the results of the analysis have to be interpreted very carefully and no firm conclusions can be drawn without further research confirming our results.

As indicated our study suggests that car drivers do not fail to give priority to motorcycles relatively more often than to another car when approaching the intersection from a perpendicular angle. They do, however, more often fail to give way to oncoming motorcycles than to oncoming cars when making a left turn. From the data we cannot recover whether this is the case because the motorcycle is less conspicuous in this situation. However, it does make sense to assume a conspicuity related explanation because of the difference between priority scenario 1 and 2. Especially when a vehicle is approaching on the same road, the front view of a motorcycle is smaller than a car. When approaching from a perpendicular angle the difference in size between a motorcycle and a car is much smaller. In addition, when a vehicle is approaching an intersection from a perpendicular angle, the car driver has more information about the speed of the approaching vehicle. The vehicle moves along the visual field (and the image on the retina changes considerably with this movement) to provide reliable information about speed. When approaching on the same road, the only information available regarding the speed of an oncoming vehicle is the increasing size of the image. Because the front view of a motorcycle is smaller than that of a car, there is relatively less information about

**Table 2**
Driving licence category of the car drivers in CD–MC crashes on intersections in the period 2006–2009 (including crashes with slight injuries and property damage only).

| | Dual CD–MC | | CD–MC | | Driver's licence unknown | | Total |
|---|---|---|---|---|---|---|---|
| | *N* | % | *N* | % | *N* | % | |
| Fail to give priority (scenario 1) | 40 | 47 | 1168 | 50 | 68 | | 1276 |
| Fail to give way (scenario 2) | 14 | 16 | 613 | 26 | 28 | | 655 |
| Other | 31 | 36 | 549 | 24 | 70 | | 650 |
| Total | 85 | 100 | 2330 | 100 | 166 | | 2581 |

*Source:* BRON.

the speed of the approaching motorcycle. Experiments with simulated traffic scenarios also demonstrated that individuals were significantly more accurate at judging the speed of an oncoming car compared with that of a motorcycle (Gould et al., 2012). In addition, the manoeuvre of making a left turn and having to give way has been designated as a difficult manoeuvre in itself. For example, older drivers experience relatively more difficulty with this manoeuvre than with other manoeuvres (Davidse, 2007). With a more difficult manoeuvre, fewer attention and resources for information processing are available for assessing speed of oncoming traffic.

We did not find a significant difference between dual drivers and regular car drivers in the proportion of crash causes on intersections. This is in contrast with previous studies on dual drivers (Brooks and Guppy, 1990; Magazzù et al., 2006). It must be noted, however, we had only few crashes with information on the drivers' licence available for analysis. Only 40 dual drivers failed to give priority and 14 failed to give way in the period 2006–2009. In addition we needed to include crashes with slightly injured or property damage only. Because the registration rate in BRON decreases when the seriousness of the crash decreases, this increases the uncertainty of the results. Perhaps in the future, and with increased registration of driving licence categories, a better analysis is possible.

Because of the uncertainties in the police registration of crashes we consider this crash analysis as explorative. However, it does point out to what can be an important shift in the way we interpret conspicuity related or "looked-but-failed to see" crashes. The introduction shows the amount of research that has been carried out in this area. However, these crashes may occur just as often with cars as with motorcycles, at least when approaching from a perpendicular angle. If this is true, the contributing factors (or solution) for these crashes should not be sought in the appearance of the motorcycle but in the procedures a car driver uses when approaching an intersection. In situations where the motorcycle is approaching on the same road, conspicuity is possibly a more important factor. Research could focus on improving the front view of a motorcycle. There have been some studies on improving the front view of motorcycles in the dark; for example by including lights on the helmet, handle bars and/or pedals forming T-shaped light configurations (Gould et al., 2012; Rößger et al., 2012). But in our opinion, these studies do not provide conclusive evidence of an enhancing effect of a T-shaped light configuration for motorcycles yet.

More research on this subject is necessary to confirm our preliminary results, and to explain the differences between the two scenarios. For example a simulator study in which a car driver approaches an intersection and conflicts with either a motorcycle or another car (from different angles) could indicate whether indeed the difference between motorcycle and car conspicuity contributes less to intersection crashes than we think. Also the analysis of Naturalistic Driving data (where car drivers' behaviour is monitored in every day live) can be useful because the number of conflicts between cars and motorcycle can be adjusted for the number of encounters.

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