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Motorcyclists' speed and "looked-but-failed-to-see" accidents

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Abstract: Previous research on motorcycle crashes has shown the frequency and severity of accidents in which a non-priority road user failed to give way to an approaching motorcyclist without seeing him/her, even though the road user had looked in the approaching motorcycle's direction and the motorcycle was visible. These accidents are usually called "looked-but-failed-to-see" (LBFS) accidents. This article deals with the effects that the motorcyclist's speed has in these accidents. It is based on the in-depth study and precise kinematic reconstruction of 44 accident cases involving a motorcyclist and another road user, all occurring in intersections. The results show that, in urban environments, the initial speeds of motorcyclists involved in "looked-but-failed-to-see" accidents are significantly higher than in other accidents at intersections. In rural environments, the difference in speed between LBFS accidents and other accidents is not significant, but further investigations would be necessary to draw any conclusions. These results suggest that speed management, through road design or by other means, could contribute to preventing "looked-but-failed-to-see" motorcycle accidents, at least in urban environments.

Keywords: Motorcycle crash Looked-but-failed-to-see –Speed -In-depth accident studies

1. Introduction

Motorcyclists comprise a category of road users that are particularly exposed to the risk of having injury or fatal accidents. In France, their risk of being killed per million kilometers travelled is approximately 25 times greater than for private passenger vehicle users (ONISR, 2010). Furthermore, according to the statistics from the French National Road Safety Observatory, motorcyclists account for 20.8% of people killed and 18% of those injured, although they only account for 3.6% of all registered vehicles (ONISR, 2010). This excess risk among motorcyclists is not specific to France; it concerns many other countries (Clarke et al., 2007; Langley et al., 2000; NHTSA, 2008; SafetyNet, 2008). Improving safety for motorcyclists is therefore a serious concern.

The literature dealing with motorcycle safety has established that one of the main types of accidents involving motorcyclists concerns priority motorcyclists driving straight ahead and whose trajectory is cut off by another road user performing a non-priority maneuver (ACEM, 2004; Clarke et al., 2007;

Hurt et al., 1981; PeekAsa and Kraus, 1996; Williams and Hoffmann, 1979; Wulf et al., 1989). Furthermore, these accidents appear to be characterized by an often high level of severity (Pai and Saleh, 2008; Pai, 2009; Peek-Asa and Kraus, 1996). It is common in these accidents for the other user to declare that he/she had looked in the direction of the motorcycle prior to undertaking his/her interfering maneuver, but did not see it even though, according to witnesses, it was visible (Williams and Hoffmann, 1979; Wulf et al., 1989). These accidents, called “looked-but-failed-to-see” accidents (Brown, 2002; Clarke et al., 2007; Herslund and Jørgensen, 2003; Koustanai et al., 2008) or “motorcycle conspicuity-related accidents” (Hurt et al., 1981; Radin Umar et al., 1996; Thomson, 1980; Williams and Hoffmann, 1979; Wulf et al., 1989) have been the subject of quite a few investigations, notably concerning the ways to improve the sensory conspicuity of motorcyclists. These studies notably demonstrated that the use of daytime running headlights by motorcyclists is an effective measure for preventing accidents related to not being perceived by another user (Elvik and Vaa, 2004; Radin Umar et al., 1996; Waller and Griffin 1981; Yuan, 2000; Zador, 1985). Other less numerous studies have sought to evaluate the effects of other types of conspicuity aids on accidents (notably fluorescent and/or retro-reflective jackets and vests, light or brightly coloured helmets). Here again, the publications suggest that these measures have a positive effect (notably see Bragg et al., 1980; Comelli et al., 2008; Hurt et al., 1981; Vaughan et al., 1977; Wells et al., 2004). The results by Wells et al. (2004), for example, suggest that wearing fluorescent and/or retro-reflective clothing is related to a significant decrease of approximately 37% in motorcyclists’ risk of injury.

However, these different conspicuity aids (lights, reflective vests, and coloured helmets) are not a failsafe remedy, insofar as they only reduce the occurrence of part of the accidents related to the low conspicuity of motorcyclists (approximately one-third for the use of daytime running headlights according to Radin Umar et al., 1996). Moreover, “looked-but-failed-to-see” accidents involving motorcyclists still occur, even though they had their headlight on and/or were wearing reflective clothing (Clarke et al., 2007; Williams, 1976). Furthermore, studies by Langham et al. (2002) suggest that a high level of sensory conspicuity (the case of parked yellow and blue police cars equipped with wide reflective strips and red and blue emergency rotating lights) does not necessarily ensure a high level of perception and that other factors, such as cognitive factors, play a major role in LBFS accidents. In an attempt to find new levers of action for accident prevention, other studies, most of them recent, have sought to identify other accident factors beyond those affecting the visual characteristics of motorcyclists and their environment. Studies by Clarke et al. (2007), for example, suggest that automobile drivers involved in “looked-but-failed-to-see” accidents with motorcyclists tend to be older. In fact, their investigations showed that the ratio of the number of automobile drivers involved in a LBFS accident with a motorcyclist in which they were considered as being mainly responsible compared with the number of automobile drivers involved in a non-LBFS accident with a motorcyclist in which they were also considered as being mainly responsible increases with the age of the automobile drivers, especially after the age of 65. Experimental studies carried out on a driving simulator or in situ led to similar conclusions: elderly drivers have greater difficulty in detecting motorcyclists (Keskinen et al., 1998; Rogé et al., 2010; Smither and Torrez, 2010). According to the authors, this tendency could be explained by the effect of age on elderly drivers’ cognitive and perceptual abilities. Notably, the specificity of their expectations could lead them to adopt strategies of information gathering and processing that concentrate on objects that their experience has taught them are relevant and neglect certain rare events and certain users with little cognitive conspicuity (Brown, 2002; Herslund and Jørgensen, 2003; Summala et al., 1996), such as an approaching motorcyclist. Thus, improving motorcyclists’ ‘cognitive conspicuity’ (Hancock et al., 1990), notably among experienced drivers, could contribute to reducing “looked-but-failed-to-see” accidents involving motorcyclists (Clarke et al., 2007; Kim and Boski, 2001). The studies by Brooks and Guppy (1990), Magazzù et al. (2006) and Weber and Otte (1980) quoted by Wulf et al. (1989), lend credit to this idea since automobile drivers with knowledge of motorcycle driving appear significantly less often to be involved in injury accidents with a motorcyclist.

The present study is in keeping with this line of research, studying the influence of another accident factor, i.e. the motorcyclist's speed in an approach situation. The hypothesis that we have tested in this study is that of the existence of a relationship between high level of speed (for the motorcyclists) and the fact that they are involved in a "looked-but-failed-to-see" accident. For a given interval of time before a potential collision between a motorcyclist and another road user, it is obvious that the higher the motorcycle's speed and the greater its distance from the other user, the smaller its apparent size in the other user's field of vision. It may then be harder to see. This hypothesis is reinforced by several experimental studies using fixed images of road scenes or in situ experiments, which have shown that automobile drivers have difficulties in detecting motorcyclists, especially when they are far away or at intermediate distances (cf. Crundall et al., 2008; Hole et al., 1996; Janoff, 1973), but do not have any more difficulties in seeing them than cars when they are close (cf. notably Crundall et al., 2008). Furthermore, the possible influence of speed on the low conspicuity of motorcyclists has been suggested by some authors (notably see Kim and Boski, 2001; Peek-Asa and Kraus, 1996; Williams and Hoffmann, 1979; or more recently, Pai and Saleh, 2008). If this influence is confirmed, this would suggest that using various means to reduce motorcyclists' speed could constitute another avenue for preventing the LBFS accidents involving them. The study presented in this communication corresponds to the consolidation of an initial study carried out on a smaller number of cases and which only dealt with urban motorcycle crashes (cf. Brenac et al., 2006).

2. Data and method

Previous research published in the literature discussing the possible relationship between motorcyclists' speed and the difficulty that other road users have in detecting them leads to this conclusion indirectly. The study by Peek-Asa and Kraus (1996), for example, showed that the 'excessive speed or speed not adapted to the situation' variable in police reports is filled in significantly more frequently for accidents in which the motorcyclist's path gets cut off by a vehicle coming from the opposite direction and turning left (accidents often related to not detecting the motorcyclist) compared with other types of multiparty motorcycle accidents (except for head-on collisions, but according to the authors these are rare).

In this study, we seek to confirm this relationship, basing our work on what is certainly a smaller number of accident cases, but using much more detailed data gathered at the accident scenes. These data provide a reliable distinction between "looked-but failed-to-see" accidents and other types of accidents, as well as a relatively accurate estimate of motorcyclists' speeds.

A sample of 44 cases (30 cases in urban areas, 14 cases in rural areas) from our in-depth accident study database (EDA—Études Détaillées d'Accidents in French) was used for this. The method used in this survey is of the "investigation on the scene of the accident" type (OECD, 1988). When an accident occurs in the sector around Salon de Provence (population: 60,000) and Aix en Provence (population: 140,000), a multidisciplinary team comprising a psychologist and a technician is informed at the same time as the emergency services and intervenes immediately on the scene of the accident. The psychologist undertakes an in-depth interview with the different people involved and with any witnesses. Each interview is recorded and is then transcribed word for word. The technician gathers data relative to the road environment (site geometry, road conditions, traffic signs, traffic conditions, skid marks, etc.) and the vehicles (final positions, deformations, positions of debris, condition of the protection systems, positions of the control levers, etc.). Photographic and video records of the accident scene are also made. After comparing the information gathered by each investigator, an initial analysis of the case is carried out and a second round of data gathering is undertaken, usually within 48 h of the accident. The psychologist undertakes a supplementary in-depth interview with the people involved and the technician returns to the accident site for

additional observations and performs a technical inspection of the vehicles. The case is then the subject of an in-depth analysis based on a sequential analysis model (Fleury and Brenac, 2001) and a kinematic reconstruction, which notably provides an estimate of the vehicles' initial speeds (Lechner and Jourdan, 1994). We should point out here that the kinematic reconstruction procedure consists in reconstructing the spatiotemporal scenario of the accident by progressively going back in time, from the final positions to the initial driving situations: using the final position of the vehicles and marks observed in the post-collision situation, the velocities after impact are estimated; on this basis, and using the energies dissipated during the collision estimated by analysing the vehicles' deformations, the impact velocities are assessed; lastly, taking into account the evidence preceding the collision, it is usually possible to determine the initial speeds of each party involved, before the driving system shifts over from a driving situation to an emergency situation.

Of course, this reconstruction work is not based on the material clues alone (skid marks, deformations), but rather on all the data gathered. The in-depth interviews with the people involved and the witnesses, the configuration of the location and observations on practices are taken into account, for example. Furthermore, given the current lack of understanding in the literature as to the dynamic behaviour of motorcycles in emergency and collision situations (Perrin et al., 2009), this reconstruction work naturally calls upon the expertise of researchers and multidisciplinary accident investigation teams and includes a certain amount of interpretation, as is often the case in this type of approach (Rosén et al., 2011).

The sample of 44 cases was obtained by selecting all cases meeting the following criteria simultaneously:

- an accident between a motorcyclist (motorcycle with at least a 125-cc engine) and another road user;
- an accident occurring in an intersection; the priority motorcyclist driving straight forward; the other road user coming from a perpendicular or opposite direction to the motorcyclist;
- a manoeuvre by the other user cutting off the motorcyclist's path.

These criteria are used to select the accident configurations most frequently involving "looked-but-failed-to-see" errors (Brown, 2002; Clarke et al., 2007; Crundall et al., 2008). We should point out that in none of these 44 cases was the other road user confronted with the motorcyclist under the influence of alcohol. Likewise, none of the 44 other road users was suffering from any ophthalmological problem that could have played a notably role in the accident. The weather conditions were normal in all cases. We should also point out that in all cases, the motorcyclist had the headlight on, and that three cases occurred at night. Public lighting was working in these three cases.

On this basis, we were then able to distinguish accidents of the "looked-but-failed-to-see" type from other accidents among the 44 cases studied. These are cases for which another user undertook an appropriate information gathering strategy by looking in the motorcyclist's direction, but failed to see the motorcyclist even though he was present in his field of vision. This point was established from the in-depth interviews undertaken by the psychologist, but also using other evidences. In particular, the motorcyclist's presence in the other user's field of vision was determined both by the kinematic reconstruction and by the witnesses' declarations or by the motorcyclist himself/herself who in some cases declares that he/she saw the other user look at him/her before undertaking his/her manoeuvre. On this basis, the initial speeds of the motorcyclists in the "looked-but-failed-to-see" (LBFS) accidents and in the other cases were compared. These other cases, which also meet all the criteria defined above, constitute a set of reference accidents (which we will call the CG: comparison group).

3. Results

Among the 44 cases studied, 18 cases correspond to LBFS accidents (9 cases in urban areas, 9 cases in rural areas). Among the other 26 cases (CG), 21 occurred in urban areas and 5 in rural areas. At this stage, it is interesting to observe that, proportionally, there are many more LBFS accidents in rural areas than in urban areas (64% and 30%, respectively, Chi-square p-value = 0.031). Tables 1 (for accidents in urban areas) and 2 (for cases in rural areas) give the mean initial speed values estimated for motorcyclists in LBFS cases and in the other cases (CG). Figs. 1 (for urban cases) and Figs. 2 (for rural cases) represent the distribution of the motorcyclists' initial speeds in terms of cumulative percentages for the LBFS cases and for the comparison cases. We should point out that, for all cases that occurred in urban areas, the legal speed limit was 50 kph. It was 90 kph for the rural cases.

For the cases occurring in urban areas, the initial speeds of the motorcyclists appear to be higher overall for LBFS accidents than for the cases in the comparison group ($p = 0.007$). We should point out that the p-value given in the table is slightly overestimated since, in the calculation of ranks, we have systematically broken the ties in favour of the null hypothesis. If we eliminate the three cases that occurred at night (two LBFS cases and one case in the comparison group), the difference between the two groups is still significant at the 0.05 threshold ($p = 0.013$).

For the cases occurring in rural areas, the mean initial speed of the motorcyclists also appears to be higher for LBFS cases. However, this difference is not statistically significant, at the 0.05 threshold ($p = 0.219$). The same conclusion would have been obtained if we had broken the ties in favour of the alternative hypothesis (the p-value would have been 0.182).

Table 1

Motorcyclists' speeds in LBFS accidents and in comparison group (CG), in urban areas (n = 30).

Accident group	Motorcyclists' speed (kph) Mean (s.d.)	Comparison (Wilcoxon–Mann–Whitney one-tailed test)
LBFS accidents (9 cases)	66.8 (12.2)	Speeds for LBFS higher than for comparison group ($p = 0.007$)
Comparison group (21 cases)	47.5 (18.0)	

Table 2

Motorcyclists' speeds in LBFS accidents and in comparison group (CG), in rural areas (n = 14).

Accident group	Motorcyclists' speed (kph) Mean (s.d.)	Comparison (Wilcoxon–Mann–Whitney one-tailed test)
LBFS accidents (9 cases)	80.3 (12.4)	Non significant ($p = 0.219$)
Comparison group (5 cases)	71.9 (15.6)	

Fig. 1. Motorcyclists' initial speed distribution, in terms of cumulative percentage, for the "looked-but-failed-to-see" accident group (LBFS) and for the comparison group (CG), in urban areas (n = 30).

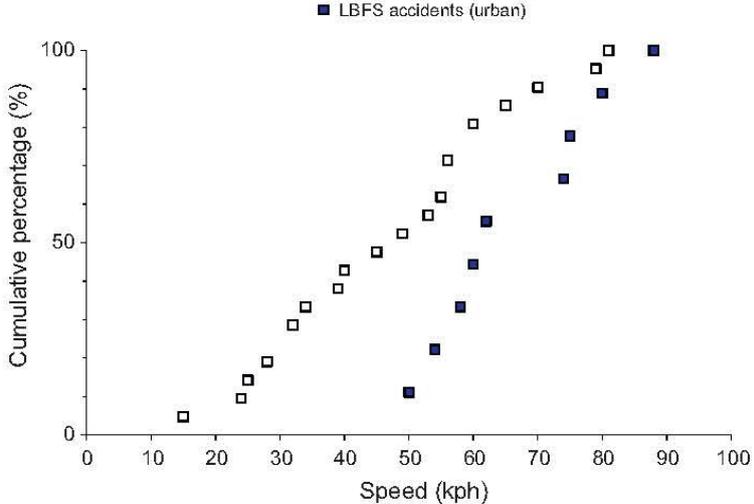
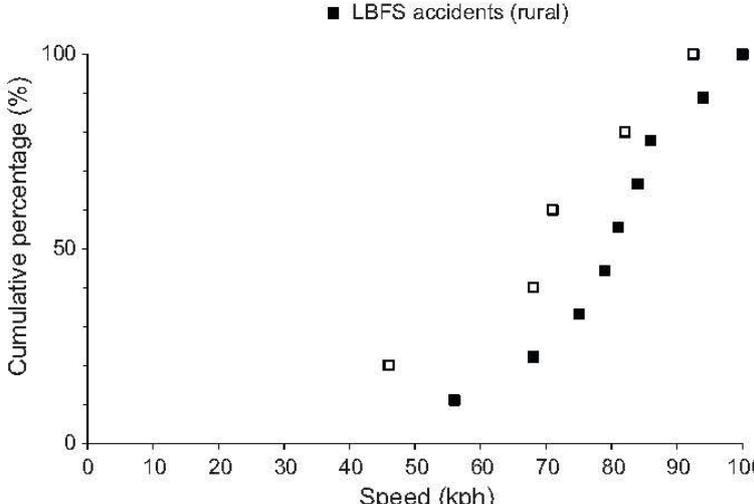


Fig. 2. Motorcyclists' initial speed distribution, in terms of cumulative percentage, for the "looked-but-failed-to-see" accident group (LBFS) and for the comparison group (CG), in rural areas (n = 14).



4. Discussion

The results we have presented here show that in urban areas, "looked-but-failed-to-see" accidents involving motorcyclists are indeed related to initial speeds (for the motorcyclists) that are significantly higher compared with those of other types of accidents in intersections. This could be explained by the unfavourable effect that the motorcycle's speed has on its apparent size in the other user's field of vision as he undertakes his manoeuvre. Indeed, for a given time separating a priority motorcyclist and another non-priority road user from a potential collision, the higher the

motorcyclist's speed and the greater his/her distance from the other user, the smaller his/her apparent size in the other user's field of vision. Furthermore, the motorcyclist's position (due to his/her speed) at the moment when the other road user undertakes to gather information can also contribute to his/her not being seen insofar as he may be in a part of the visual scene not directly explored (central vision) by the other user, as it does not correspond to the standards of the common intersection interaction situations experienced (Duncan, 1996; Summala et al., 1996). A similar study on speeds at work in LBFS accidents involving cars would be very instructive from this point of view.

In rural areas, the difference in initial speeds between LBFS accidents and other accidents is not significant. We cannot exclude the idea that this absence of any significant difference is simply the result of a lack of statistical power, given the small number of cases comprising the comparison group (5 cases). Further investigations, notably using a larger number of cases, would consequently be needed.

Lastly, we should point out the small proportion of LBFS accidents in urban areas compared with rural environments. This tendency suggests that, in rural areas, the diversity of accident mechanisms in intersections between motorcyclists and other users is significantly lower than in towns, where the many different situations, layouts, users and their interactions lead to more of the other types of accidents than LBFS, generally at lower speeds. This research has certain limits, however. In particular, the number of cases studied is relatively small (especially for accidents in rural areas). This is in part due to the nature of the data used: on-scene, in-depth investigations require us to limit the geographical sector of intervention so the investigation team can get to the sites very quickly. The number of accident cases occurring in such a sector for a given type of accident is therefore quite small. In return, this kind of data provides an in-depth understanding of each case and can be used for a kinematic reconstruction of the accident.

Concerning the consequences of this research in terms of prevention, the results of this study suggest that speed management, for example using road design strategies ("traffic calming" techniques) or enforcement strategies, could constitute an interesting avenue for indirectly improving motorcyclists' perceptibility, at least in urban environments. The positive effect of these measures on injury accidents has been established (Elvik and Vaa, 2004). Concerning their effects on urban injury accidents involving motorcyclists, before-and-after assessments are still needed. We can nonetheless mention the study by Christie et al. (2003), who observed a 63% decrease in injury accidents involving motorcyclists after setting up a network of 101 mobile speed cameras (mostly on roads where the speed limit is 30 mph) in the South Wales region of the UK. Concerning traffic-calming approaches, Webster and Mackie (1996) observed that implementing 72 traffic-calming schemes (20-mph zones) led to a reduction of approximately 73% in the mean rate of motorcycle crashes. If these effects were to be confirmed, these strategies could contribute to preventing "looked but-failed-to-see" accidents involving motorcyclists, at least in urban environments.

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