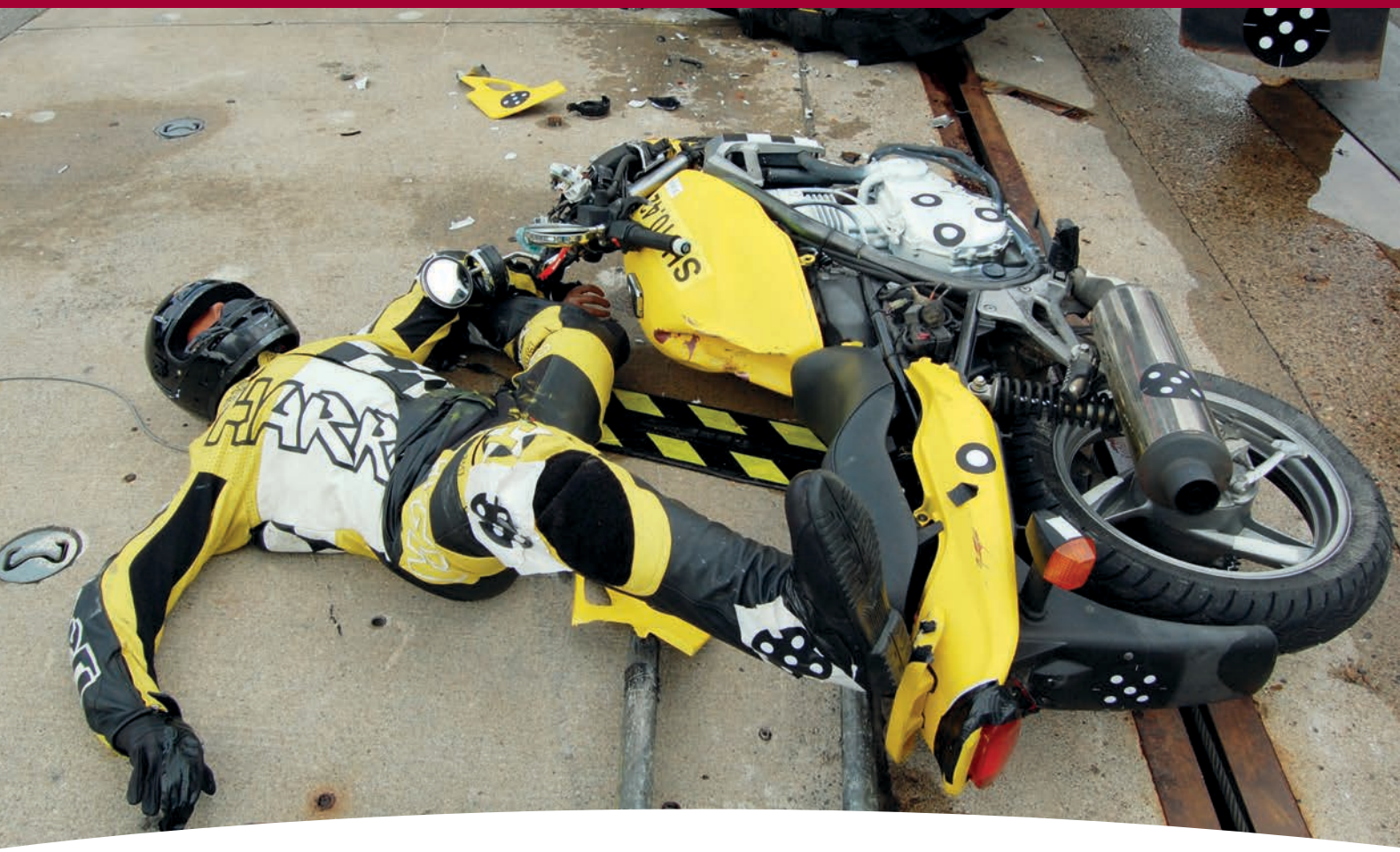
German Insurance Association No. 5



Compact accident research

An analysis of motorcycle accidents

Unfallforschung der Versicherer
GDV

Impressum

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German Insurers Accident Research

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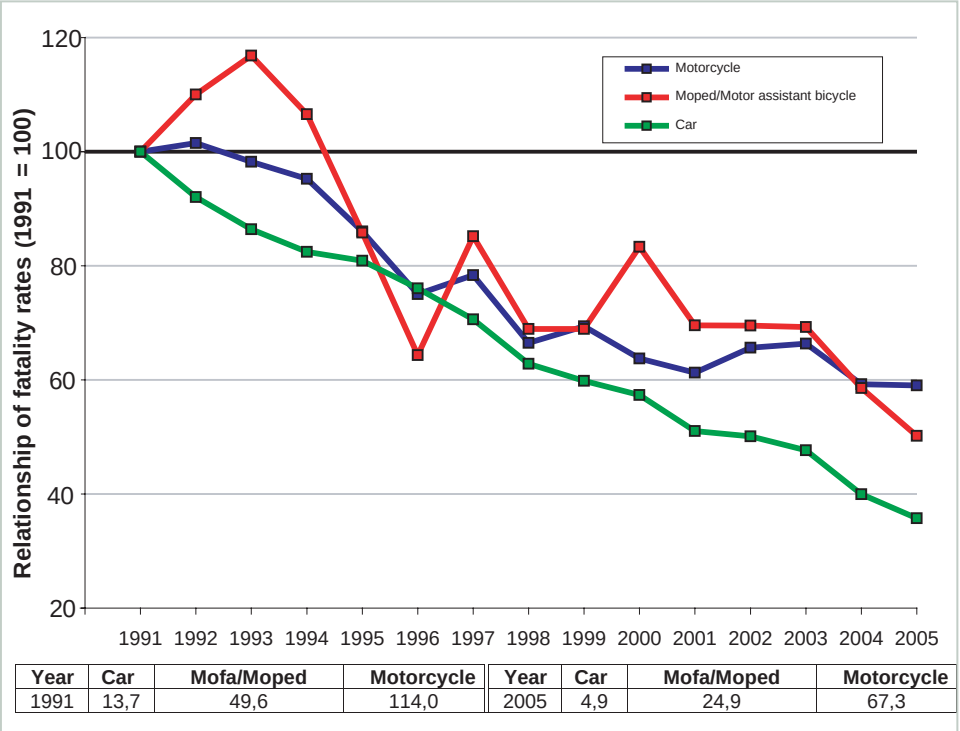
Photo references: Insurers Accident Research and source references

Published: 11/2008
First revised edition: 09/2009

Preface

The driving-related risk of being killed in an accident is 14 times higher for motorcyclists than the risk for passenger car users (Germany, 2005). This risk had increased even further over the last years to the disadvantage of motorcyclists.



Year	Car	Mofa/Moped	Motorcycle	Year	Car	Mofa/Moped	Motorcycle
1991	13,7	49,6	114,0	2005	4,9	24,9	67,3

Illustration 1:
Development of fatility rate of motorcyclists and users of mopeds/motorised two-wheelers in comparison to passenger car users [1] and [2]

The number of road users killed in fatal road accidents in Germany dropped by 55% from 1991 to 2006. Motorcyclists however benefit from this development far less than other road users. Whilst there has been a decrease of 61% in respect of motor vehicle users, the figure for motorcyclists has seen a drop of only 20%. For this reason the Insurers Accident Research (UDV) commissioned by the Loss Prevention Commission and in cooperation with the TU Berlin's Department of Motor Vehicles and the TU Dresden's Professorship for Road Traffic Technology conducted research into the accident risk of motorcyclists from a new perspective of linking vehicle- and road traffic technology for the first time [3]. The objective was to establish technical and road-related factors which influence the event of the accident as well as the severity of injuries of the motorcyclists [3]. This is in order to apply targeted measures to reach a more equitable situation between the development of traffic safety for motorcycle users on the one hand and the generally positive development in Germany on the other hand. This interdisciplinary approach provides consensual recommendations for the vehicle user, the vehicle and the road. The results of these investigations are summarised in a research report.

Content

Data basis

In addition to a national analysis of over 100,000 accidents with motorcycle involvement which was used for the definition of the target group, in-depth analyses were conducted in Saxony, because the histories of motorcycle accidents in the latter federal state proved to be representative (Illustration 2 and Illustration 3).

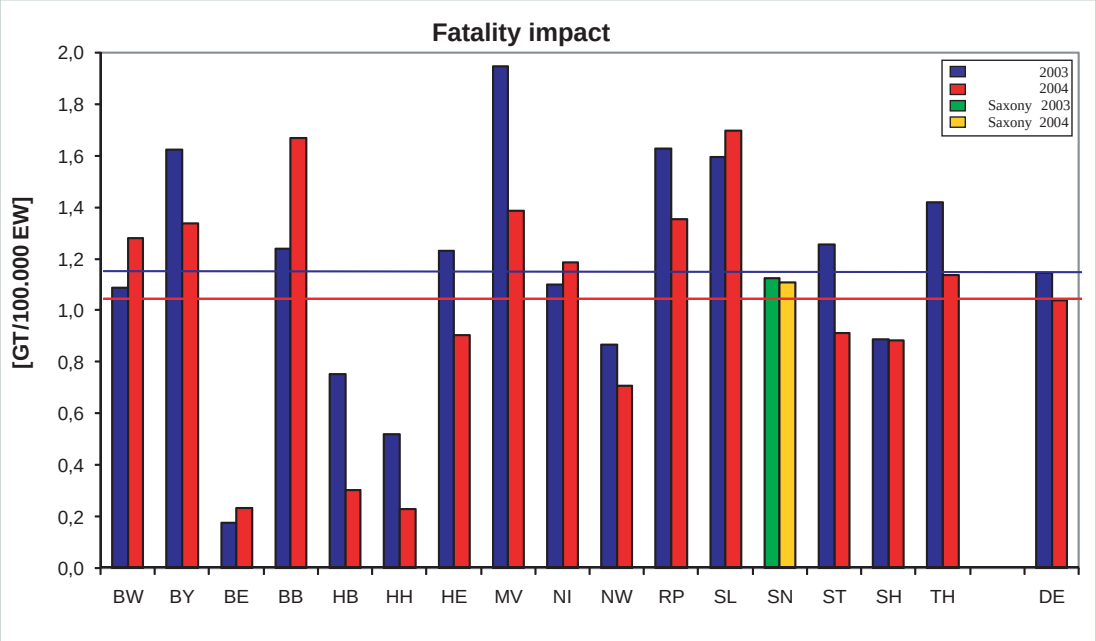


Illustration 2:
Fatality impact according to federal states i.r.o. accidents with motorcycle involvement 2003 and 2004

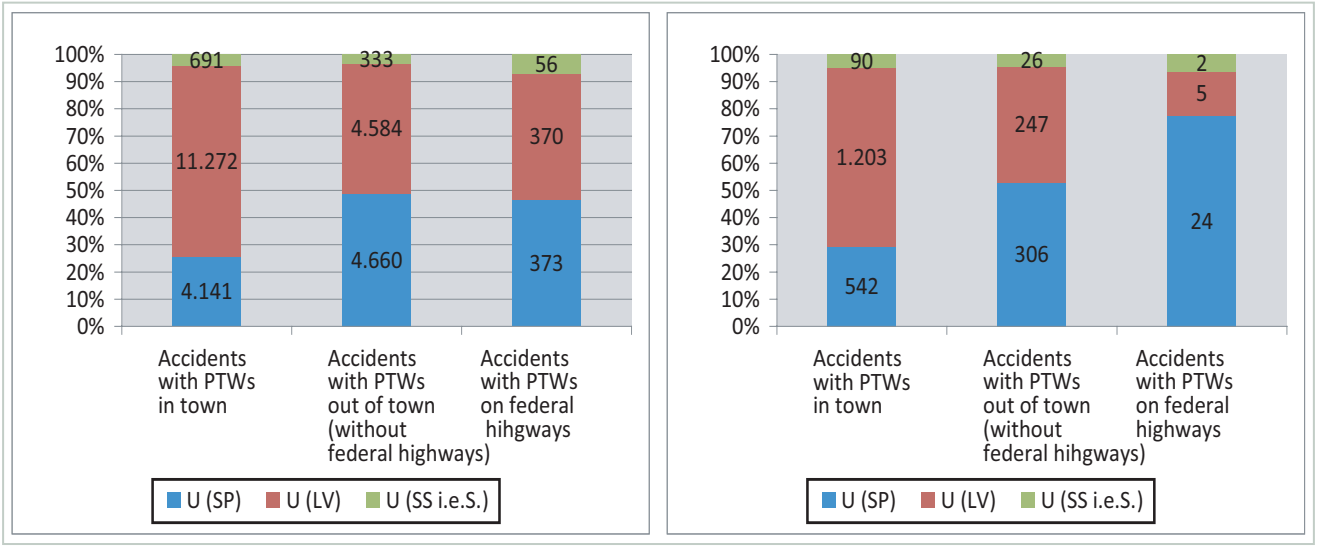


Illustration 3:
Comparison of the accident severity distribution in Germany (left) and Saxony (right) for the year 2005 i. r. o. accidents involving powered two-wheelers

Table 1:
Accident-prone road characteristics

Out of town (ago)	In town (igo)
Location of bumps (vertical curves) in curves or at intersections	Road defects
high degree of curves	Tramway traffic conducted in traffic lanes
Road sections with long inclines	

The more than 12,000 accidents registered by police involving motorised two-wheelers in Saxony from 2004 to 2006 form the basis for the detailed local investigations conducted. 219 road sections with 1,622 accidents were selected and paired off for purposes of comparison. Half of the road sections came to the attention because of a disproportionately high incidence of motorcycle accidents, and were paired off with comparable road sections, which did not generate any such attention. Of these, 126 road sections with a total of 530 motorcycle accidents were inspected and analysed in terms of their local conditions.

It demonstrated that those points listed in Table 1 count markedly to those road circumstances contributing to motorcycle accidents.

On the vehicle side more than 1,300 sets of data taken from the German Insurers Accident Research's accident data base were evaluated in order to describe the specific influences of vehicle features and driver behaviour. Only third party liability claims with personal injury and a claims expenditure of more than 15.000 Euro were considered. In addition a survey was conducted amongst motorcyclists, which permits for conclusions to be drawn about the behaviour of motorcycle riders in traffic.

Typical accident constellations

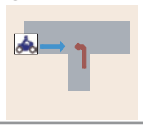
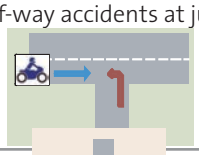
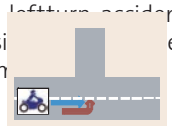
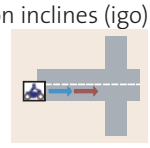
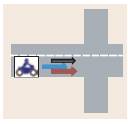
Typical accident histories can be constructed on the basis of location, local characteristics of the accident scene, type of accident and kind of accident. For these accident constellations connections to the vehicle- and driver characteristics are established and suitable recommendations deduced [3]. Consequently the constellations thus deduced form 41 % of all accidents investigated with serious personal injury ($n_{total,\ U(SP)}$ = 427) and 44 % of accidents with personal injury ($n_{total,\ U(P)}$ = 1022). Relating to all U(SP) that are 36 % of all analysed U(SP) out of town ($n_{total,\ U(SP),\ ago}$ = 205) and 46 % of all analysed U(SP) in town ($n_{total,\ U(SP)igo}$ = 222).

The typical accident constellations and the corresponding measures are listed in Table 2.

Survey of Motorcyclists

In order to gather information on the driving behaviour of motorcyclists a questionnaire was developed in which about 40 aspects relating to the attitude towards motorcycling, the number of traffic violations committed and accidents suffered, as well as the resulting injuries are covered. In combination with the technical characteristics of the respective vehicles and the individual personal diffe-

Table 2:
Suggested measures related to deduced accident constellations

Accident constellation	Measures
1. Accidents in  go) with no other road users i 	- an area free of obstacles on the outside of the curve - Removal of passive safety measure not required - Application of passive safety measure that are motorcycle-friendly
2. Accidents (igo)er road users involved	- Repairing road damage in traffic lanes - Increasing clarity of alignment (especially in darkness) - Speed limit and -control (applies especially to riders of powered two-wheelers)
3. Accidents (igo) without a particular location profile 	- Repairing road damage - Training of the drivers of powered two-wheelers (esp. in braking) - Promoting motorcycles featuring ABS
4. Right-of-way accidents at intersections or junctions (igo) 	- No facilitation of parking bays or parking areas on primary traffic lanes in the vicinity of junctions - Improved training of novice drivers (in particular driving at night)
5. Right-of-way accidents at junctions (ago) 	- Inspection of inconspicuous junctions for identification, comprehension and sight - Removal of objects limiting sight - Speed limits and -control (applies to esp. the drivers of powered two-wheelers on the primary or main road)
6. Right- or le  nts at intersections (igo) and cooncoming vehicle	- Implementation of a separate phase for left-turning traffic - Awareness training i.r.o. motorcyclists for the other party involved in the accident
7. Right- or left-turn accidents at junctions and collisi  e driving parallel in the san	- Facilitation of left-turn lanes on the primary access roads - Training drivers of powered two-wheelers that overtaking in the vicinity of junctions is prohibited -Awareness training i.r.o. motorcyclists for the other party involved in the accident
8. Rear-end accidents at intersections, junctions or on inclines (igo) 	- Improved training of novice drivers (esp. braking) - Promoting motorcyles featuring ABS
9. Longitudinal accidents (igo) involving a collision with vehicles moving laterally in the same direction 	- Training of awareness for both the motorcyclist riding the powered two-wheeler and the other party involved in the accident

rences of the respective motorcycle owners, the empirical data basis is to provide clarity as to how far certain noticeable abnormalities exist in respect of particular groups of persons or vehicle categories.

Data collection took place exclusively in the internet under www.motorradumfrage.de from 19.01.2007 until 18.02.2008. The appeal for participation in the survey was printed in the form of a double page reference to the project in the magazine "MOTORRAD" (Issue 03/07). Given a print-run of 146,000 copies and 6,879 respondents with partially incompletely filled-out questionnaires a response of 4.7 % was achieved. The return of 5,297 fully completed questionnaires still results in a response rate of 3.6 %.

Of the 5,297 motorcyclists submitting fully completed questionnaires, 2,983 respondents had suffered an accident. This represents a share of 56.3 %. The female share of responses is 5.5 % (n = 293). Of these only 105 female motorcyclists had been involved in an accident. This represents a share of 35.8 %.

The questionnaire offers a conclusion regarding the estimated number of unreported cases where the police did not record the accidents: of the 2,555 reported accidents in which details were made available, 49 % were not recorded by the police. 69 % of these were single vehicle accidents. A consideration of only those accidents in which the motorcyclist was injured, results in a number of unreported cases of 33 %. This figure drops to 14 % when considering only those accidents with seriously injured motorcyclists.

Distribution by age

When considering the age distribution (Illustration 4) of the respondents who participated in the survey, it can be recognised that even

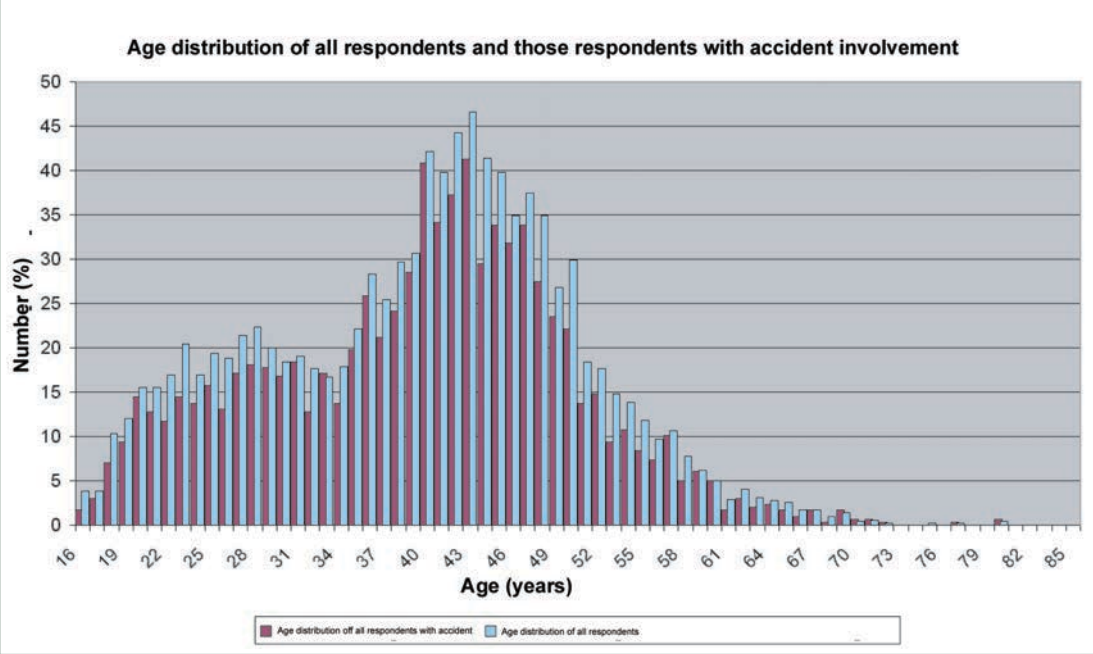


Illustration 4:
Age distribution of all respondents

here the general trend of the aging motorcyclist is manifested.

The majority of motorcyclists are between 35 and 50 years old. When considering the age distribution of the motorcyclists involved in an accident in the sample, it is noticeable that no age group is particularly under- or overrepresented.

Motivation for riding a motorcycle

Nearly half of the responses to the question why motorcycles are being ridden focussed on the driving dynamics of the motorcycle. Thus, for example, driving through bends and acceleration were stated as prime motivations for motorcycling. The achievable top speed as such is only of subordinate relevance given the 8 % response. A second main motivation for riding a motorcycle is the freedom experienced whilst doing so (Illustration 5).

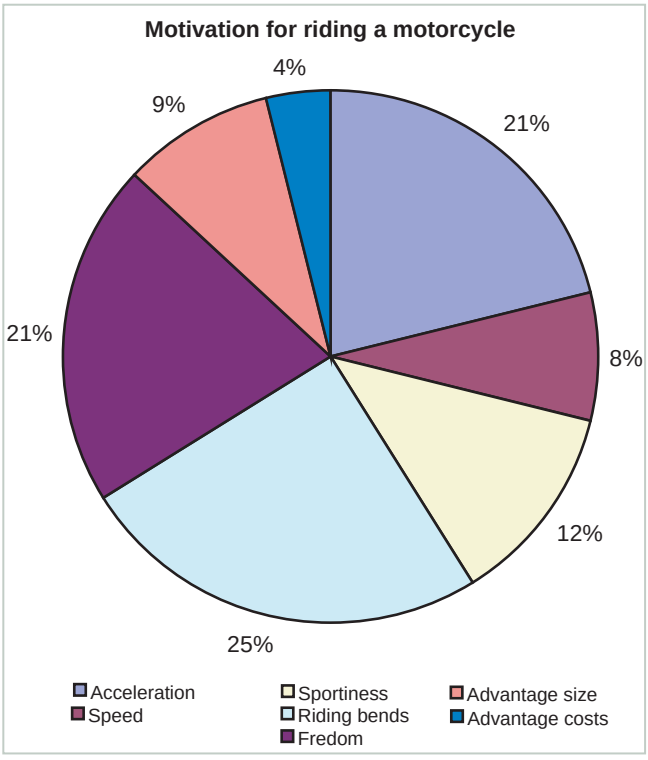


Illustration 5:
Motivation for riding a motorcyle

Considering the responses in a differentiated way according to the type of motorcycle (Illustration 6), it becomes clear that riders of the different motorcycle classes expect their modes of transportation to meet different requirements and for this very reason use a specific type of motorcycle. Chopperriders value especially the freedom that a motorcycle affords them, whilst the riders of sportsbikes, when compared to the other segments, increasingly view the sportiness and speed of their bikes as being of central importance. The most obvious deviation can be found in the scooter segment. This group of respondents emphasised especially the advantages of cost and size.

Traffic violations

In order to establish a correlation between traffic conspicuousness and accident frequency/intensity, motorcyclists were also questioned on the traffic violations committed. 1,138 of all 5,297 respondents hat at least one traffic violation. For a comparison to be drawn between the different motorcycle segments, the respective individual cases were evaluated on the basis of the response frequency in this part of the survey. Thus it can be recognised that riders of sportsbikes take upon themselves a considerably higher risk of being caught for committing a traffic offence than riders of other types of motorcycles (Illustration 7). Traffic violations thus committed are, for example, speeding or insufficient following distances.

The majority of violations committed fall in the category of speeding. This is followed by offences relating to incorrect overtaking and defects at motorcycles.

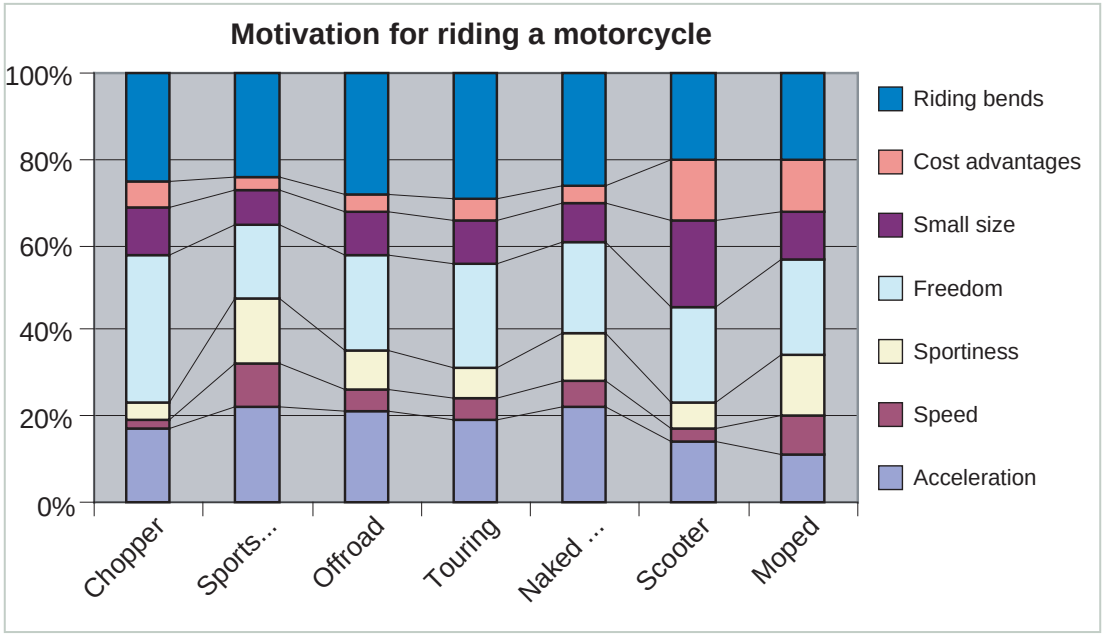


Illustration 6:
Differentation in the motivation for riding a motorcycle according to motorcycle type

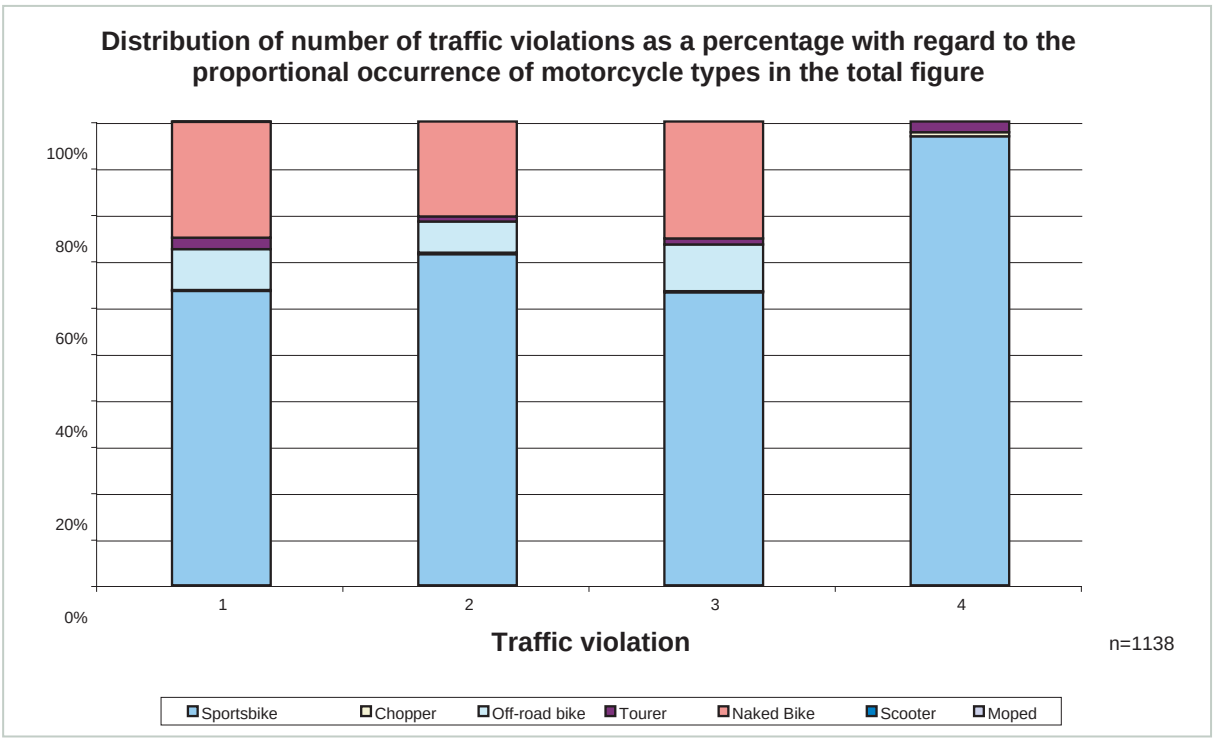


Illustration 7:
Number of traffic violations of respondents with regard to the type of motorcycle

Furthermore the following accident related findings can be deduced out of the survey:

- Between different type of accidents there are no significant differences regarding age, kilometres driven per year, power-to-weight ratio and number of traffic offences
- Motorcyclists with accident background rank their ability to drive higher than motorcyclists without accident background
- Motorcyclists with accident background describe their way of driving more sporty than accident-free motorcyclists
- Motorcyclists with accident background had significant more traffic offences during the last 3 years
- The chance to be in an accident with a ABS equipped motorcycle is clearly lower compared to a non-ABS motorcycle
- The chance to be involved in an accident with a modified motorcycle is higher compared with a non-modified motorcycle. This is particularly true for modified sportsbikes and off-road bikes.

Influence of power-to-weight ratio

A British study [4] has found that the power-to-weight ratio of motorcycles involved is the most influential factor in the accident scenario. It combines several technical characteristics of the motorcycle which describe the acceleration capacity of the vehicle. Displacement and the nominal rotation speed have a direct impact on the maximum performance of a combustion engine. Additionally a light motorcycle permits higher acceleration with equal torque, the value of the capacity to accelerate increases with a decreasing power-to-weight ratio [kg/kW]. For this analysis datasets our of accident database of German Insurers Accident Research were used.

Table 3:
Age groups

Age group	Class
under 18 years	1 (n = 10)
18 to 25 years	2 (n = 18)
26 to 40 years	3 (n = 34)
over 40 years	4 (n = 25)

Table 4 :
Capacity classes

Power-to-weight ratio $\left[\frac{kg}{kW}\right]$	Class
below 2.75	1 (n = 16)
2.75 to 4.13	2 (n = 31)
4.13 to 9.42	3 (n = 24)
above 9.42	4 (n = 16)

In order to analyse the relations of power-to-weight-ratio and injury severity more in detail a analysis of variance was conducted.

On the basis of this analysis of variance in all out-of-town accidents the correlation between the dependent variables – injury severity (MAIS) – and several independent variables was checked. In doing so the location, the issue the accident being caused by the motorcyclist, the age of the motorcyclist, and the power-to-weight ratio of the motorcycle were evaluated. In respect of the independent variable of power-to-weight ratio and age a reduced number of classes are formed (Table 3 and Table 4).

Altogether the above mentioned independent variance explain 42.6 % of the total variance in the injury severity of the motorcyclist, within the used dataset.

In these there is a correlation between the power-to-weight ratio and injury severity. Applying the post hoc test demonstrates that only class 1 shows a significantly higher injury severity than the remaining classes. Classes 2 to 4 do not differ in terms of the injury severity. The latter means, based on used data set, that riders of motorcycles with a power-to-weight ratio of below 2.75 kg/kW suffer more severe injuries.

The type of accident correlates also with injury severity. However this factor can not be influenced directly in order to reduce injury severity.

Conclusion and perspective

The results of the different specialist fields present a clear picture of motorcycle accidents. The motorcyclist must take potential mistakes by other road users into consideration. It has to be clear to him/her that not every car driver is able to judge the dynamics and the considerable acceleration capacity of a two-wheeler correctly. Accordingly driver training sessions are essential which focus especially on the mental

Illustration 8:
Working hypothesis for increasing safety in powered two-wheelers (right) deduced from vehicle concepts already realised
Sources: Piaggio (left), BMW (centre), UDV (right)

aspects and not only on the control over the motorcycle. These have to focus on teaching anticipatory driving. Also all other road users have to better incorporate specifics of motorcyclists.

An initiative has been launched in this regard with the "German Safety Tour", which is supported by the UDV (www.german-safety-tour.de).

As far as the vehicles themselves are concerned the possibilities for improvements remain rather limited. It is clear that the anti-braking system (ABS) is an important technical safety system for a motorised two-wheeler.

Furthermore as far as passive and active safety is concerned, no clear points for improvement could be identified. Possibly the combination between concepts already implemented to increase active safety in two-wheelers (Illustration 8 left) and their passive safety (Illustration 8 centre) could form the basis for an approach towards a safe vehicle (Illustration 8 right). The approach is based on a crash cage with a belted driver and an energy-absorbing front as well as two wheels at the front, permitting higher brake capacity and an increase in vehicle stability and/or reduction in the risk of crashing without neglecting the typical driving behaviour required when riding two-wheelers.

The results of the motorcycle study are summarised in a research report [3].

Links:

http://www.unfallforschung-der-versicherer.de/Unfallforschung/PR/pr_meldung_2507_2008_sitze.htm

http//www.unfallforschung-der-versicherer.de/Unfallforschung/FS/Pkw/pkw_sitztest_08.htm

List of abbreviations

ago	Out-of-town
AIS	Abbreviated Injury Scale
BAB	Bundesautobahn / Federal highway
EW	Inhabitant
GT	Fatility
igo	In town
MAIS	Maximum value of the abbreviated injury scale
MZR	Motorised two-wheeler
PTW	Powered-two-wheeler
UD	Accident density
U (P)	Accident with personal injury
U (S)	Accident with damages
U (SS)	Accident with serious damages
U (SP)	Accident with serious personal injury

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[2] Traffic in numbers (2005/06): German Federal Ministry of Traffic, Building and Urban Affairs, Deutscher Verkehrs-Verlag GmbH, Hamburg

[3] Maier, R., Schindler, V., Unger, M., Körner, M., Scholtz, Th., Kühn, M. (2008): Unfallgefährdung von Motorradfahrern, research report. 2009

[4] Elliot, M.A.; Baughan, C.J.; Broughton, J.; Chinn, B.; Grayson, G.B.; Knowles, J.; Simpson, H. (2003): Motorcycle safety: a scoping study, TRL Report TRL581. 2003

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