German Insurance Association No. 55

Typical Cyclist-Car Accidents

Compact accident research

Unfallforschung der Versicherer

GDV

Contents

Preliminary remarks

In the last 10 years, the number of people killed on the roads has fallen significantly. That is true not just in Germany but also in the European Union as a whole [1]. However, the picture for cyclists is not quite as positive. In Germany in 2013, for example, 43% fewer road users were killed than in 2004. Fatalities among car occupants fell by as much as 51%, whereas those among cyclists fell by only 25%. The improvement in cyclists' safety thus has not kept pace with the general trend. However, future technical systems in cars (such as emergency brake assist systems with cyclist detection) will have a positive effect on the accident statistics of cyclists. Before such systems can be designed, however, it is essential to have detailed information on how cyclist-car accidents happen and the course they take. The purpose of this paper is to add to this information.

This paper was presented on the 24th ESV Conference 2015 [2].

Database of the UDV

The UDV (German Insurers Accident Research) is a department of the GDV (the Gesamtverband der Deutschen Versicherungswirtschaft e.V. or German Insurance Association). It has access to all of the third-party vehicle insurance claims reported to the GDV. In 2013, for example, there were 3.9 million of these claims [3]. For the purposes of accident research, the UDV has created a database (the UDB) that contains a representative cross-section of the data (from the years 2002 to 2010) in this large pool. The data collected is conditioned for interdisciplinary purposes to facilitate research in the fields of vehicle safety, transportation infrastructure and behavior on the roads. The UDB is based on the contents of insurers' claim files. Around 700 to 1,000 new cases are added to the UDB each year. Only accidents with personal injury and a total claim value of 15,000 euros or more are added to the UDB.

Description of the cyclist accident material

Areas of impact on the car

In 356 of the total of 407 cyclist-car accidents it was possible to ascertain what part of the car was involved in the impact with the bicycle. The distribution of the areas of impact was as follows:

- Front of the car: 218 cases (61%)
- Left-hand side of the car: 55 cases (15%)
- Right-hand side of the car: 69 cases (20%)
- Rear of the car: 14 cases (4%)

Areas of impact on the car and the cyclist's maximum level of injury severity

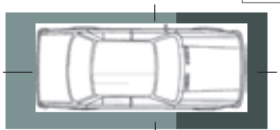
If we group together all of the impacts between the bicycle and the front part of the car (the front of the car plus the left- and right-hand front wings), we get the following picture **(Figure 1)**:

- Front part of the car: 299 cases (84%)
- Passenger compartment plus left-hand rear wing: 23 cases (6%)
- Passenger compartment plus right-hand rear wing: 20 cases (6%)
- Rear: 14 cases (4%)

Figure 1 indicates how seriously the cyclists were injured in collisions involving each of these areas of impact. Figure 1 clearly shows that measures to improve the safety of cyclists need to be focused primarily on the front of the car. This is true in relation to both the frequency of the impacts and cyclists' maximum level of injury severity [4]

MAIS	No.	%
0	0	0
1	4	28.6
2	5	35.7
3	3	21.4
4	2	14.3
5	0	0
6	0	0
Total	14	100 %
n.c.	0	
9*	0	

MAIS	No.	%
0	0	0
1	7	30.4
2	12	52.2
3	4	17.4
4	0	0
5	0	0
6	0	0
Total	23	100 %
n.c.	0	
9*	0	



MAIS	No.	%
0	0	0
1	2	11.1
2	13	72.2
3	2	11.1
4	0	0
5	1	5.6
6	0	0
Total	18	100 %
n.c.	0	
9*	2	

MAIS	No.	%
0	0	0
1	50	16.8
2	159	53.5
3	63	21.2
4	19	6.4
5	4	1.4
6	2	0.7
Total	297	100 %
n.c.	2	
9*	0	

n.c. = not clear; 9* = fatally injured, MAIS unknown

Figure 1: Maximum levels of injury severity (MAIS) in the cyclists by area of impact on the car

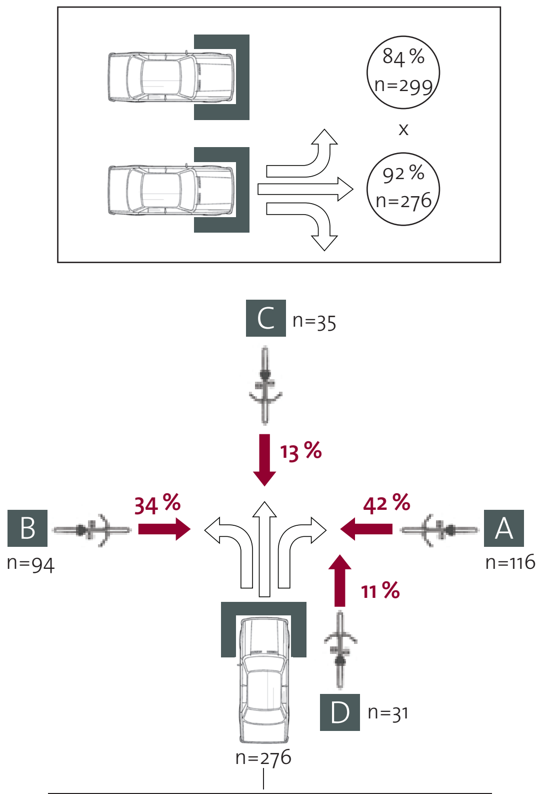
Typical accident scenarios in cyclist-car accidents

Figure 1 illustrates that most collisions between bicycles and cars involve impact with the front part of the car (n = 299 cases). In 23 of these cases the car was parked. Consequently, only 276 cases are included in our consideration of typical accident constellations. Thus, both parties involved were in motion at the time of the accident in these remaining cases. **Figure 2** shows four different impact constellations, to which all the observations that follow apply:

- **A**:The car is traveling straight ahead or turning left or right, and the bicycle is coming from the right.
- **B**: The car is traveling straight ahead or turning left or right, and the bicycle is coming from the left.
- **C**: The car is traveling straight ahead or turning left or right, and the bicycle is approaching head-on.
- **D**: The car is traveling straight ahead or turning left or right, and the bicycle is moving in the same direction.

Constellation A is the most common one (with 116 cases), followed by constellation B (94 cases) and then constellations C (35 cases) and D (31 cases).

The box in the upper part of Figure 2 shows the subset of the cyclist-car accident material to which the information in the main part of Figure 2 applies. The same principle applies to the boxes in Figures 3 to 5.



	Share of MAIS 2+	228	83 %
	Share of MAIS 3+	81	30 %
A	Share of MAIS 2+	91	79 %
	Share of MAIS 3+	34	30 %
B	Share of MAIS 2+	81	86 %
	Share of MAIS 3+	25	27 %
C	Share of MAIS 2+	30	86 %
	Share of MAIS 3+	10	29 %
D	Share of MAIS 2+	26	84 %
	Share of MAIS 3+	12	39 %

Figure 2: Frequency of different impact constellations at the front part of the car with the corresponding distributions of MAIS 2+ and MAIS 3+ in the cyclists

Speeds of the cars and bicycles and severity of the cyclists' injuries

Figure 3 shows the average speeds of the cars for these four constellations. The average speeds of the cars in constellations A, B and C were very similar (19 km/h to 23 km/h), while for constellation D the average speed was significantly higher (51 km/h).

The different speeds of the cars are also reflected in the maximum level of severity of the injuries of the cyclists involved in the accidents: The percentage of serious to fatal injuries (MAIS 3+) in constellation D was thus significantly higher (at 39%) than in constellation A (30%), constellation B (27%) or constellation C (29%). As shown in Figure 2, however, constellation D is the least common of the accident constellations investigated here (at 11%). The insurers' claim files often contain no information, or only very vague information, on the speeds of the cyclists immediately before the collision with the car, which is why these cannot be specified here. However, in an observational study on the speeds of almost 20,000 cyclists [5], the UDV found that their average speed on a clear run was 18.6 km/h. Moreover, the speed measurements indicated that cyclists on mountain bikes (at 20.5 km/h) and road or racing bikes (25.5 km/h) were significantly faster than average, and cyclists on "Dutch" bicycles (17.0 km/h) were significantly slower. The average speed of cyclists on city bikes (18.3 km/h) was about the same as the average speed for all cyclists, and the same can be said for riders of pedelecs 25 (electric-assist bicycles), whose average speed was 18.5 km/h.

Typical accident scenarios in cyclist-car accidents

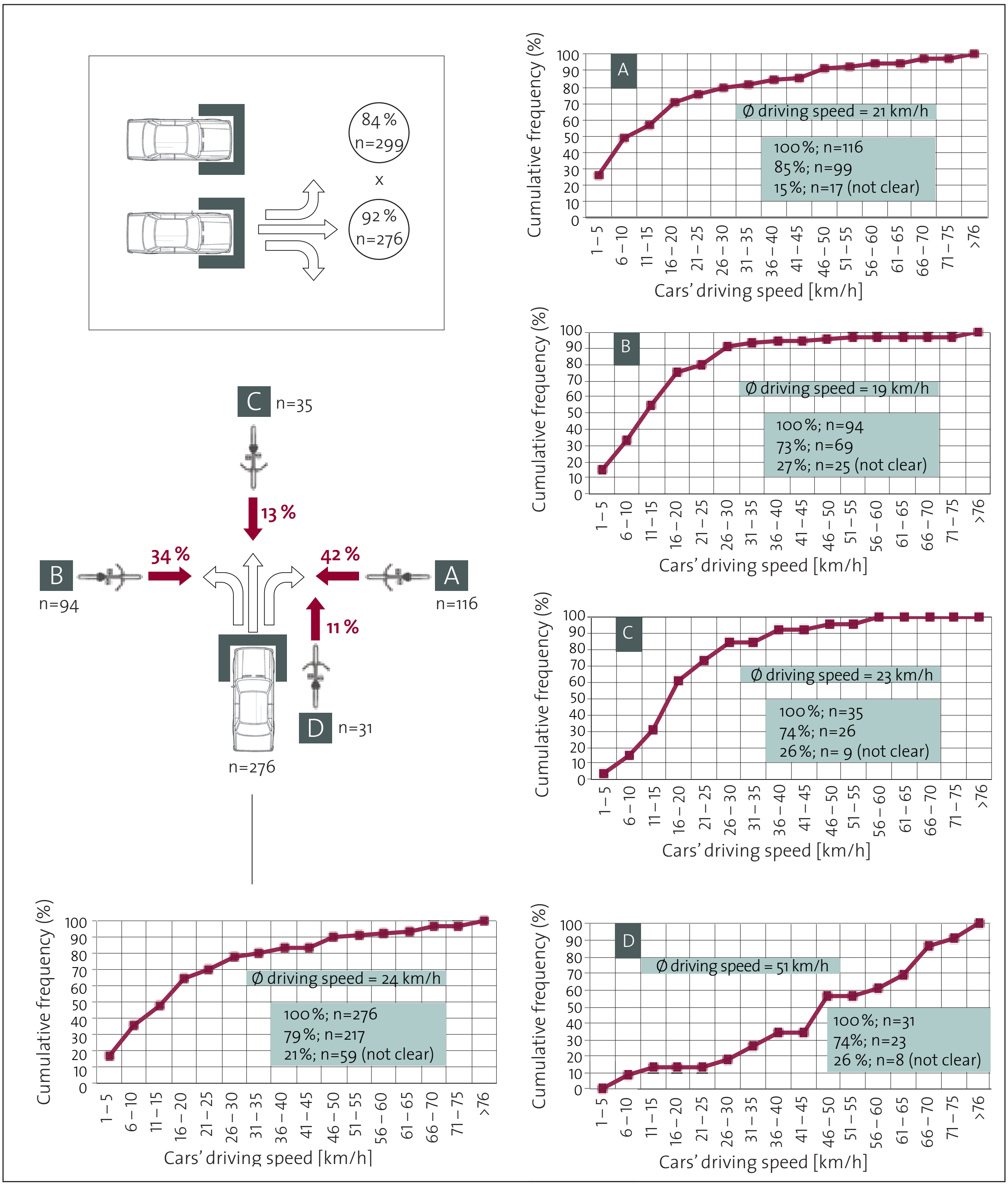


Figure 3: Average speeds of the cars by impact constellation

In-depth analysis of the two most common accident constellations

It can be seen from Figures 2 and 3 that accident constellations A (116 cases) and B (94 cases) are clearly more common than the other constellations in this accident material. These two accident constellations will be described in depth below.

Accident constellation A, bicycle coming from the right:

Accident constellation A can be subdivided into three separate scenarios (see **Figure 4**):

- A1: The car is turning left, and the bicycle is coming from the right.
- A2: The car is traveling straight ahead, and the bicycle is coming from the right.
- A3: The car is turning right, and the bicycle is coming from the right

Accident scenarios A2 and A3 occur with almost exactly the same frequency, accounting for 46% and 45% of the cases. Scenario A1, on the other hand, occurs much more rarely (9%). The lower part of Figure 4 sets out concrete situations for each of the three accident scenarios (A1, A2 and A3) that show the circumstances of the cyclist-car collision in more detail.

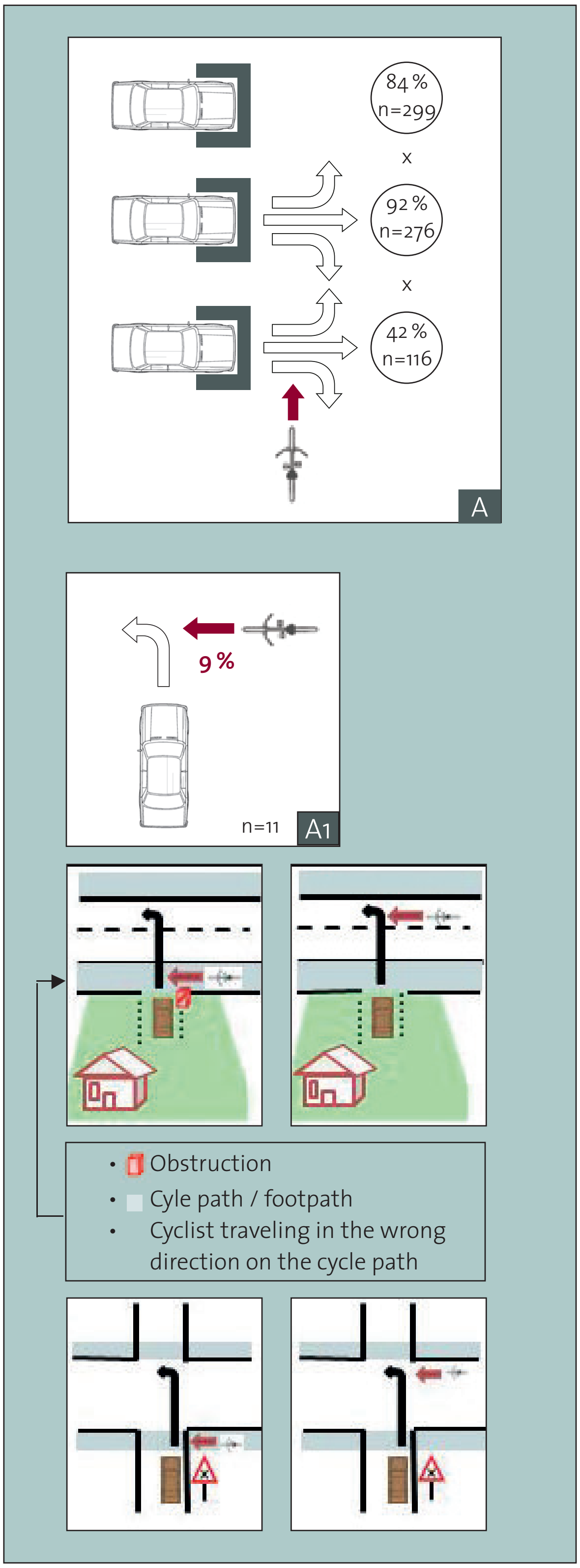
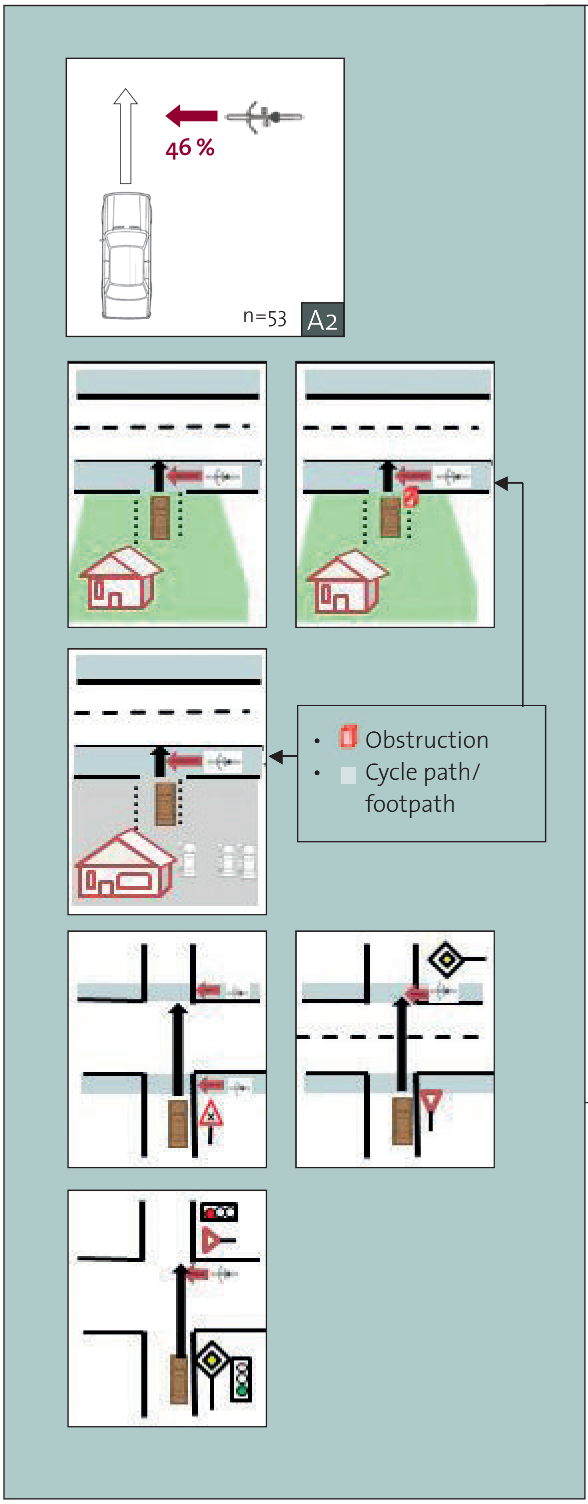
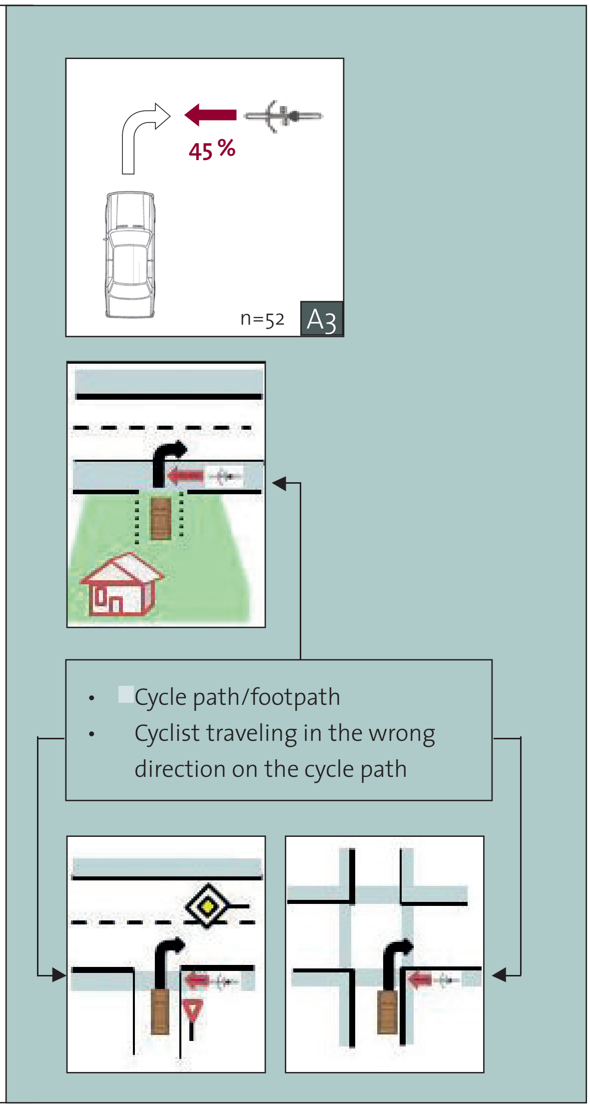


Figure 4: (on the right and the following page) Distribution of accident scenarios A1, A2 and A3 and illustration of typical cases

Typical accident scenarios in cyclist-car accidents





The following are typical accident scenarios for A1:

- The car is coming out of an exit and wants to turn left into the road. A cyclist is approaching from the right on the footpath or cycle path and is partially or totally concealed by an obstruction (such as a hedge or wall).
- The car is coming out of an exit and wants to turn left into the road. A cyclist is approaching from the right on the road.
- The car is turning left at an intersection and collides with a cyclist coming from the right.

The following are typical accident scenarios for A2:

- The car is coming out of an exit straight onto the road. A cyclist is approaching from the right on the footpath or cycle path and in some cases may be concealed by an obstruction (such as a hedge or wall).
- The car is coming out of a parking lot (of a supermarket, for example) straight onto the road.
  A cyclist is approaching from the right on the footpath or cycle path.
- The car is traveling straight ahead across an intersection and collides with a cyclist coming from the right on the footpath, cycle path or road.

The following are typical accident scenarios for A3:

- The car is coming out of an exit and wants to turn right into the road. A cyclist is approaching from the right on the footpath or cycle path.
- The car is turning right into a road where the traffic has priority and collides with a cyclist coming from the right on the footpath or cycle path.
- The car is turning right at an intersection and collides with a cyclist coming from the right on the footpath or cycle path.

Accident constellation B, bicycle coming from the left:

Like accident constellation A, accident constellation B can also be subdivided into three separate scenarios (see **Figure 5**):

- B1: The car is turning left, and the bicycle is coming from the left.
- B2: The car is traveling straight ahead, and the bicycle is coming from the left.
- B3: The car is turning right, and the bicycle is coming from the left.

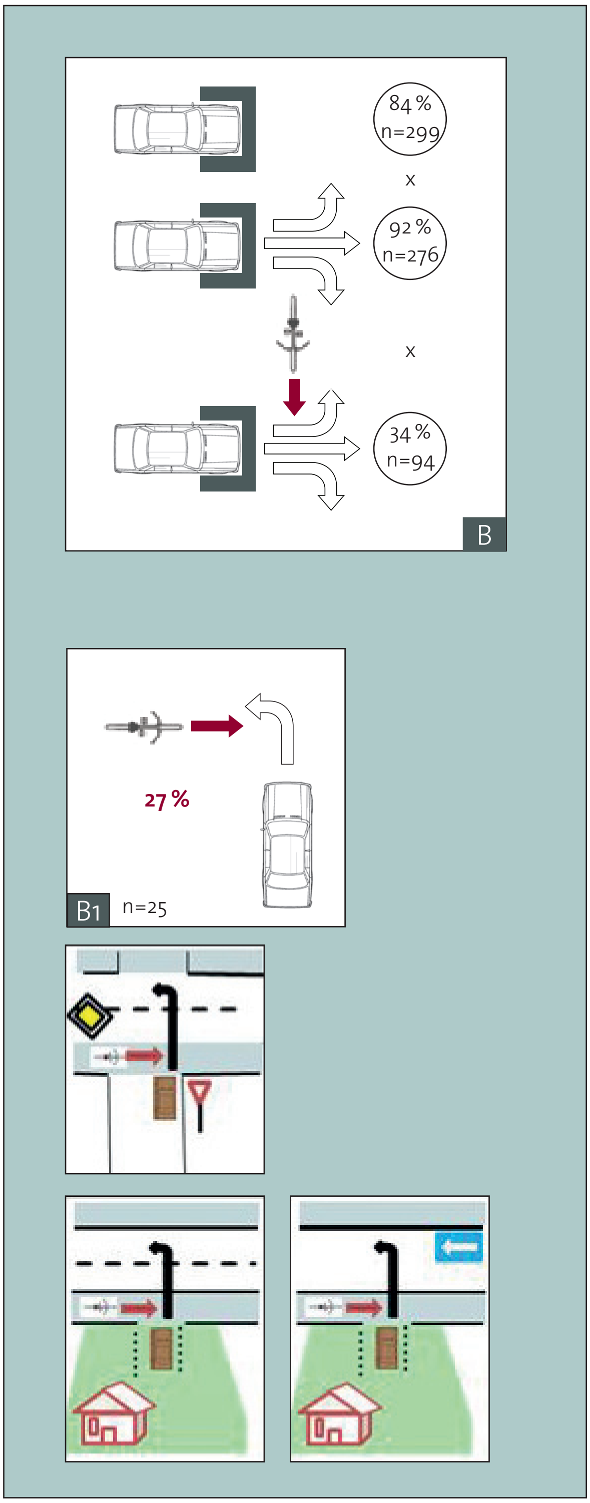
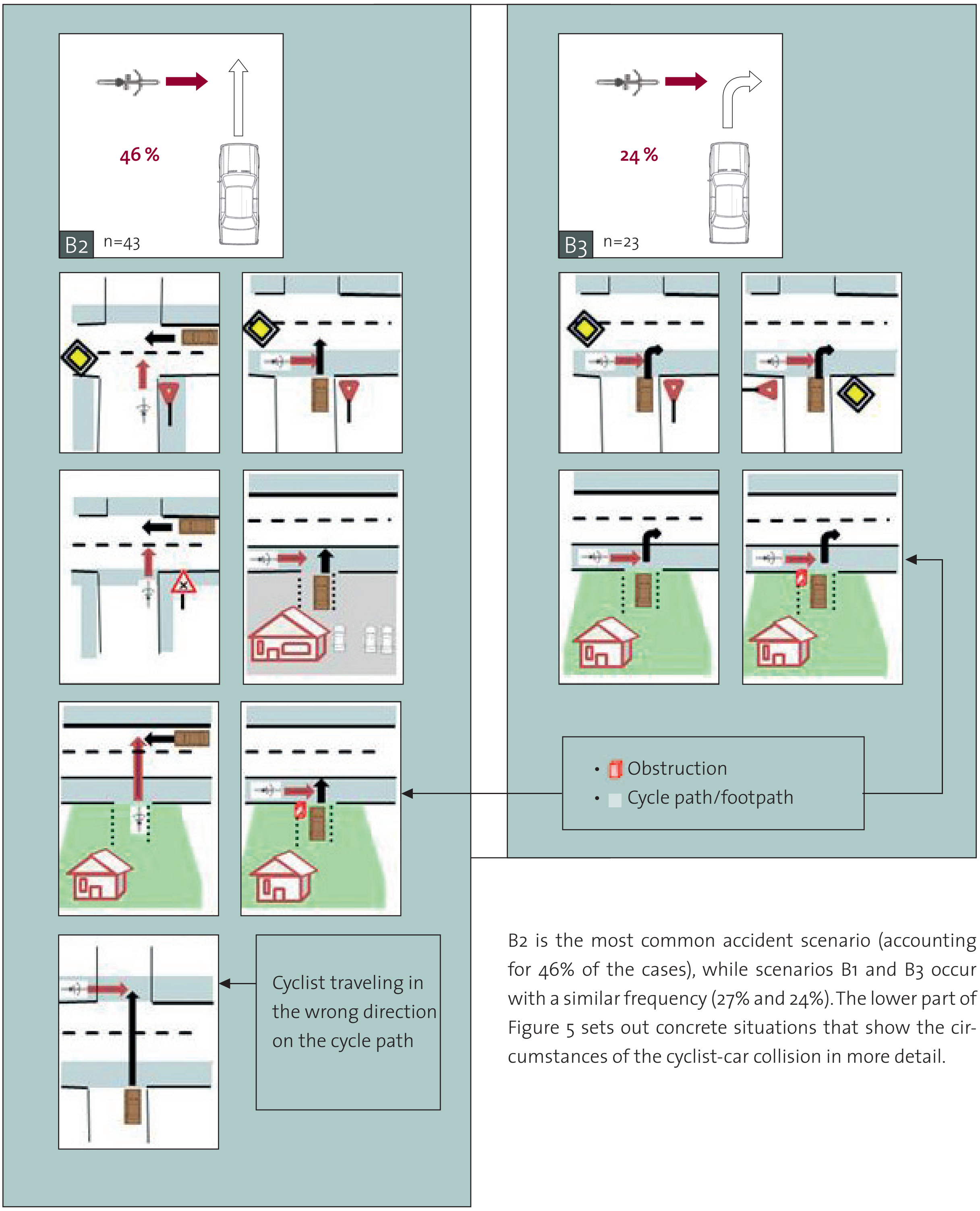


Figure 5: Distribution of accident scenarios B1, B2 and B3 (on the following page) and illustration of typical cases

Typical accident scenarios in cyclist-car accidents



B2 is the most common accident scenario (accounting for 46% of the cases), while scenarios B1 and B3 occur with a similar frequency (27% and 24%). The lower part of Figure 5 sets out concrete situations that show the circumstances of the cyclist-car collision in more detail.

The following are typical accident scenarios for B1:

- The car, which does not have priority, is turning left at an intersection and collides with a cyclist coming from the left on the footpath or cycle path.
- The car is coming out of an exit and wants to turn left into the road or one-way street. A cyclist is approaching from the left on the footpath or cycle path.

The following are typical accident scenarios for B2:

- The car is traveling straight ahead across an intersection and collides with a cyclist coming from the left on the footpath, cycle path or road.
- The car is coming out of an exit or a parking lot onto the road. A cyclist is approaching from the left on the footpath or cycle path and in some cases may be concealed by an obstruction (such as a hedge or wall).
- The car is traveling straight ahead on a road and collides with a cyclist who comes out of an exit on the left.
- The car is traveling straight ahead across an intersection and collides with a cyclist coming from the left on the other side of the road.

The following are typical accident scenarios for B3:

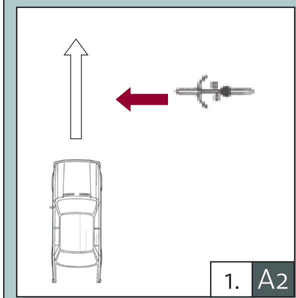
- The car is turning right at an intersection and collides with a cyclist coming from the left on the footpath or cycle path.
- The car is coming out of an exit and wants to turn right into the road. A cyclist is approaching from the left on the footpath or cycle path and in some cases is concealed by an obstruction (such as a hedge or wall).

Summary assessment of the three most common accident scenarios

In addition to the findings described in this paper, a range of further analyses were also carried out and assigned to the various accident scenarios. Moreover, extrapolation factors were used to extrapolate the cyclist-car accident material described here to all claims reported to the GDV. When all these findings are combined, the picture shown in **Figure 6** is obtained: Scenarios A2 and A3 are the most common, followed by B2. These three scenarios alone account for 42% (15% + 15% + 12%) of all cyclist-car accidents.

Two out of three A2 accidents take place at entrances or exits, the average speed of the car is 30 km/h, and the driver does not brake in 55% of all cases. In scenario A3, 85% of the collisions between cyclists and cars take place at entrances or exits, and the driver does not brake in three of every four cases. This suggests that the driver either does not see the cyclist or does not have enough time to brake. The average speed of the car in scenario A3 is 11 km/h. The percentage of entrances and exits involved in scenario B2 is also very high (47%). The average speed of the cars in scenario B2 is 27 km/h, and the driver does not brake in 42% of the collisions. Further characteristics of scenarios A2, A3 and B2, such as light conditions, the condition of the road and the injury severity and age distribution of the cyclists, are also shown in Figure 6.

Typical accident scenarios in cyclist-car accidents

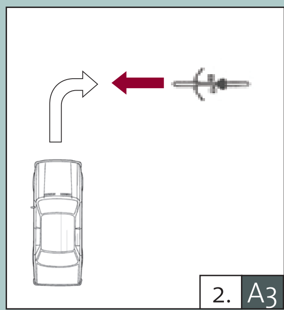


Szenario A2 :

***11 %** (±2.6%) of all cyclist accidents
***15 %** (±3.5%) of all cyclist-car accidents
*18% (±4.4%) of all cyclist-car accidents where the main point of impact is on the front part of the car

- Location: 62 % at junctions and entrances/exits of properties or parking lots
- Movement type of cyclist = cycling
- Cars' average speed = 30 km/h
- Car braked before accident = no in 55 % of cases
- Injury severity of cyclists = 70 % serious
- Light conditions = 85 % daylight
- Road surface conditions = 85 % dry
- Age distribution of cyclists = 19 % (13-19); 17 % (41-47)

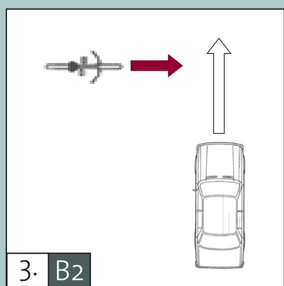
*: Using case-dependent extrapolation factors based on stratification variables of the case material



Szenario A3 :

***11 %** (±2,1%) of all cyclist accidents
***15 %** ±3.5%) of all cyclist-car accidents
***17 %** (±4.3%) of all cyclist-car accidents where the main point of impact is on the front part of the car

- Location: 85 % at junctions and entrances/exits of properties or parking lots
- Movement type of cyclist = cycling
- Cars' average speed = 11 km/h
- Car braked before accident = no in 75 % of cases
- Injury severity of cyclists = 62 % serious; 38% minor
- Light conditions = 88 % daylight
- Road surface conditions = 81 % dry
- Age distribution of cyclists = 21% (55-61); 17% (41-47); 13% (48-54); 13% (62-68)



Szenario B2 :

***9 %** (±2.4 %) of all cyclist accidents
***12 %** (±1.9%) of all cyclist-car accidents
*14% (±3.9%) of all cyclist-car accidents where the main point of impact is on the front part of the car

- Location: 47% at junctions and entrances/exits of properties or parking lots
- Movement type of cyclist = cycling
- Cars' average speed = 27 km/h
- Car braked before accident = no in 42% of cases
- Injury severity of cyclists = 74% serious
- Light conditions = 88% daylight
- Road surface conditions = 79% dry
- Age distribution of cyclists = 16% (62-68); 14% (6-12); 12% (41-47)

*: Using case-dependent extrapolation factors based on stratification variables of the case material

Figure 6: The three most common accident scenarios, their significance in relation to all cyclist accidents and characteristic features of these accident scenarios

Conclusions

In the past, researchers focused primarily on pedestrians rather than other unprotected road users. However, cyclists are now becoming an increasingly important focus of research. In 84% of the cases in the UDV's cyclist-car accident material, the impact between the bicycle and the car occurred at the front part of the vehicle. The most common accident scenarios are "cyclist coming from the right" and "cyclist coming from the left". There are only a few cases in which the car is behind the bicycle and hits the back of it. In this impact constellation, however, serious to fatal injuries (MAIS 3+) occur more often than in other impact constellations. Accidents in which the cyclist is coming from the right or left very often occur at the entrances or exits of properties or parking lots and at junctions. It is essential to take this into account when developing advanced driver assistance systems designed to prevent collisions between cars and cyclists – but also when developing test procedures. Poor light or road conditions, on the other hand, are of only minor significance.

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Notes

Notes

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