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Compact accident research

Turning-off accidents between motor vehicles and cyclists

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Preliminary remarks

One in four people killed on the roads in built-up areas is a cyclist. Turning-off accidents are the most common type of accident after turning-into/crossing accidents. The UDV (German Insurers Accident Research) carried out a project to investigate turning-off accidents between cyclists cycling straight ahead and motor vehicles turning right or left. Both the road infrastructure and the behavior of road users in turning-off situations were examined with regard to their effect on accidents and road safety.

The studies conducted in the cities of Münster, Magdeburg, Darmstadt and Erfurt revealed that around 80 % of accidents of this type result in injuries. Injuries are six times more common in this accident type than in accidents as a whole.

The study shows that there is a need for action with regard to the design and layout of the infrastructure, encouraging road users to behave safely on the roads and improving their knowledge of the rules of the road.

Based on the project‘s findings, recommendations are made for a safe road infrastructure and cycling facilities at intersections in built-up areas as well as on how to instruct and educate drivers and cyclists. In addition, recommendations are also made as to how driver assistance systems might be (further) developed.

Contents

1 Introduction

Around 27 % of all people killed on the roads in built-up areas in 2011 were cyclists. Accidents involving cyclists thus represent the second most common accident situation in Germany after those involving car occupants [1]. Injuries very often occur in these accidents, and cyclists are often seriously or fatally injured. When it comes to accidents involving injury, turning-off accidents are the second most common accident constellation after turning-into/crossing accidents, accounting for up to 20 % of accidents involving cyclists. A number of studies of accidents involving cyclists have revealed this (including [2], [3], [4] and [5]).

Turning-off accidents in built-up areas between motor vehicles and cyclists were therefore examined in more detail in a UDV research project designed to investigate turning-off accidents involving cars/trucks and cyclists. The investigation focused on accidents in which motor vehicles turning off to the right (near side) or left (off side) collided with cyclists cycling straight ahead (referred to below as turning-off accidents involving cyclists).

Both the road infrastructure and the behavior of all road users have to be taken into account when considering road safety. Given the considerable variety of infrastructure configurations for cycling at intersections, it is worth analyzing the accident statistics to investigate which of them ensure a high level of road safety, and which of them are particularly unfavorable or even unsuitable.

The behavior of road users is also an important factor in whether accidents occur in turning-off maneuvers. The German road traffic regulations (StVO) clearly regulate the behavior of road users in these situations. They stipulate that a vehicle that is turning off must give way to a cyclist cycling straight ahead. However, the accident statistics demonstrate that this rule is often violated.

This publication presents the results of the UDV project investigating turning-off accidents involving cars/trucks and cyclists. The aim of the project was to develop recommendations for:

- The safe design and layout of the road infrastructure at intersections in built-up areas
- The instruction and education of drivers and cyclists
- The (further) development of driver assistance systems

2 Methodology

In order to investigate the accidents and conflicts that occur between motor vehicles turning off a road and cyclists cycling straight ahead, the literature was analyzed, macroscopic and microscopic accident analyses were carried out, behavior was observed, and onsite surveys and telephone interviews were conducted (table 1).

Following an extensive analysis of the literature, Münster, Magdeburg, Darmstadt and Erfurt were chosen for the investigation. These four cities differ in terms of the percentage of road users accounted for by cyclists and the level of importance of cycling. From a total of around 6,300 turning-off accidents that occurred in the four cities included in the investigation from 2007 to 2009, 873 accidents were found to be conflicts involving motor vehicles that were turning off and cyclists who were cycling straight ahead. These accidents were analyzed macroscopically.

The investigations into the influence of the infrastructure on accidents and conflicts

Table 1:
Methodology

Section of the study	Step
Problem analysis and preliminary work	▪ Analysis of the literature ▪ Selection of cities
Macroscopic accident analysis	▪ Procurement of police accident data ▪ Cleansing of accident data ▪ Calculation of adjusted accident cost data ▪ Macroscopic accident analysis
Infrastructure-related accident analysis	▪ Inventorying of the infrastructure ▪ Clustering of the intersection legs ▪ Ascertainment of traffic volumes and usage of parts of the infrastructure ▪ Infrastructure-related macroscopic accident analysis ▪ Infrastructure-related microscopic accident analysis
Investigation of behavior on the road	▪ Selection of the intersection legs to be investigated ▪ Behavioral observation ▪ On-site survey ▪ Telephone survey
Combination and interpretation of the results, production of recommendations	

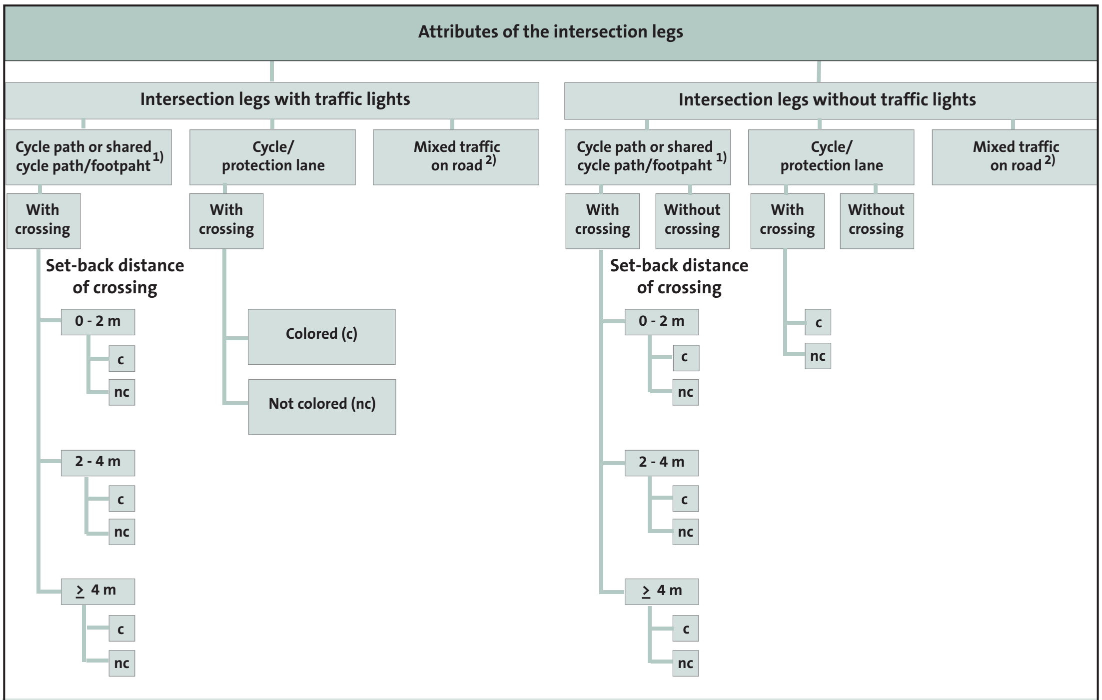
were carried out at the level of individual intersection legs. For this purpose the cycling infrastructure at intersections in the network of main roads and main cycling routes in the four cities were analyzed on the basis of aerial photographs. The infrastructural attributes of over 8,000 intersection legs were recorded.

In order to identify infrastructural and operational attributes shared by intersection legs that might be significant in relation to turning-off accidents involving cyclists, the roads were subdivided into clusters. The clusters were formed depending on whether the roads had traffic lights, on the layout and configuration of the infrastructure for cycling, on the distance by which the cycle crossing was set back from the road to which it ran parallel (set-back distance) and on the appearance (colored or not) of the cycle crossing (figure 1). It was possible to assign around 5,000 intersection legs to one of these infrastructure clusters. These were used to obtain the accident frequencies per cluster[1)] in the infrastructure-related accident analysis.

In a microscopic accident study involving on-site inspections of all intersection legs with at least two turning-off accidents involving cyclists 453 accidents at 151 intersection legs were analyzed microscopically.

At 43 intersection legs, behavior was additionally observed using three synchronized video cameras, and the speed of the drivers and cyclists was recorded (figures 2 and 3). 23 intersection legs with more than two turning-off

1) The accident frequency gives the number of accidents at intersection types of a cluster divided by the number of roads at these intersection types in the cities included in the study. The accident cost frequency takes accident costs into account in the same way.



1) The cluster ˝cycle path or shared cycle path/footpath“ includes corresponding cycling infrastructure regardless of whether or not their use is mandatory.
2) The designation ˝mixed traffic on road“ is used for the sake of simplicity. This is used to describe roads shared by cyclists and motor vehicles that do not have any special markings for cyclists (no cycle lanes or protection lanes).

Figure 1:
Clustering of intersection legs with and without traffic lights[2)]

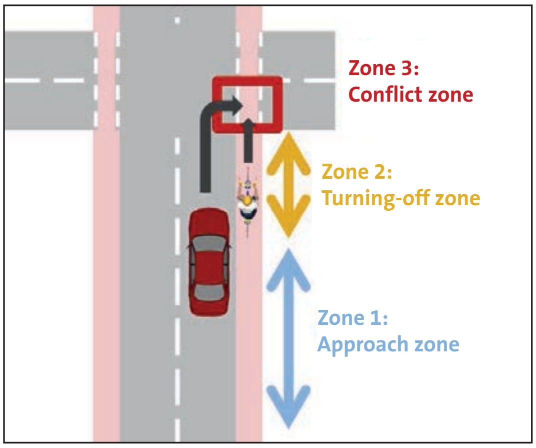


Figure 2:
Zones for the observation of behavior

accidents involving cyclists and 17 accident-free intersection legs were studied. Interactions between drivers and cyclists were found to occur in around 12 % of all turning-off cases. There were 708 interactions, and conflicts occurred in 10 % of these cases.

In addition, a representative telephone survey of 200 drivers and 200 cyclists was conducted in the cities included in the study. They were asked about their subjective feelings of safety with regard to different cycling infrastructure configurations, their own behavior and their knowledge of the rules of the road.

2) The following are not included in the analysis and thus not taken into account in the clustering: cycling facilities on intersection legs with traffic lights that do not have a marked cycle crossing (and are thus not consistent with the rules for main roads), intersection legs that have a free lane combined with a triangular island for turning off to the right (negative effect on cycling safety known from previous research projects), roundabouts and entrances (special circumstances as far as traffic is concerned).

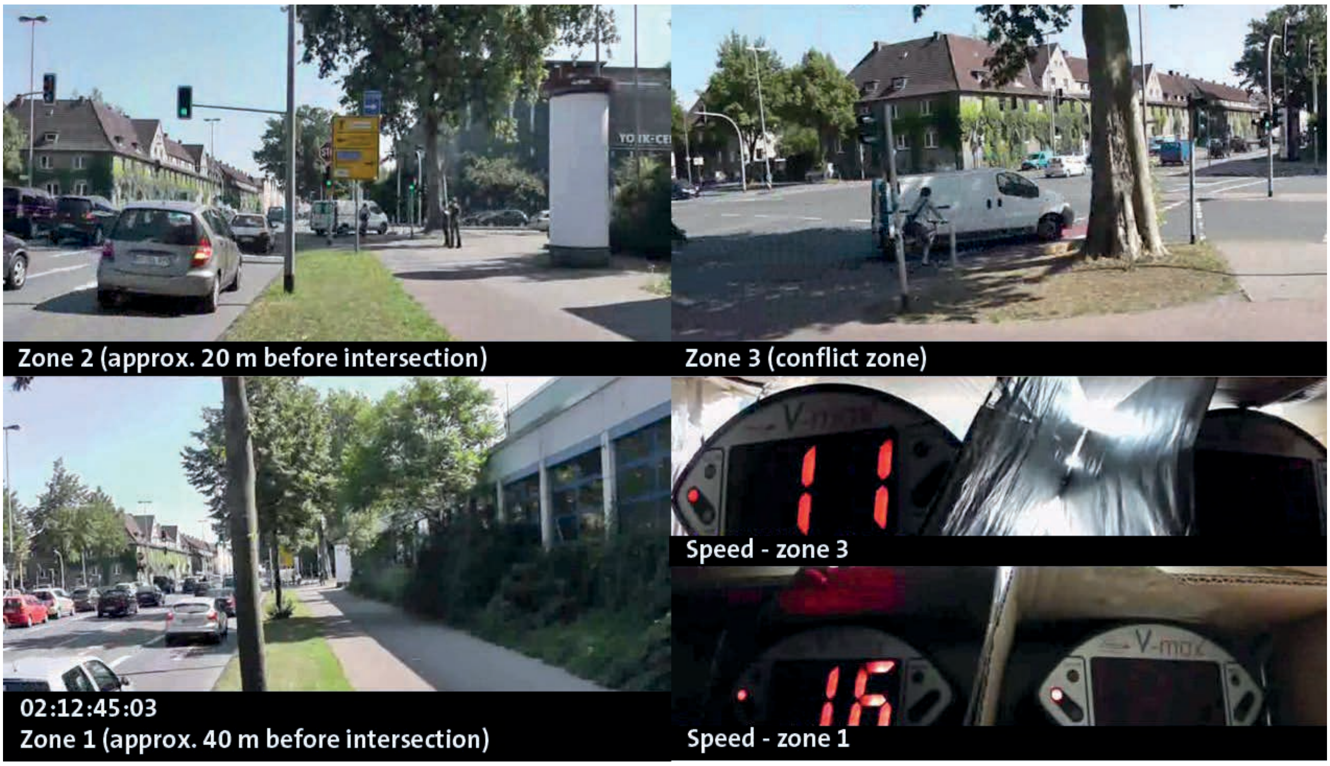


Figure 3:
Video images for the observation of behavior and speed measurement

3 Accidents between motor vehicles turning off the road and cyclists cycling straight ahead

Around 43 % of the accidents involving injury that occurred in the four cities included in the study from 2007 to 2009 were accidents involving cyclists. Around 15 % of these involved cyclists cycling straight ahead and motor vehicles turning off to the left or right. This accident constellation was the second most common cause of accidents involving cyclists and injury after turning-into/crossing accidents.

The risk of injury in turning-off accidents involving cyclists was six times higher than for accidents as a whole and 10 % higher than for accidents involving cyclists as a whole. Looking at turning-off accidents alone, around one in three turning-off accidents involving injury was an accident between a cyclist cycling straight ahead and a motor vehicle turning off to the left or right.

The analysis of the 873 turning-off accidents involving cyclists in the cities included in the study revealed that most of them (almost 71 %) fell into accident category 3 (accident with minor injuries).

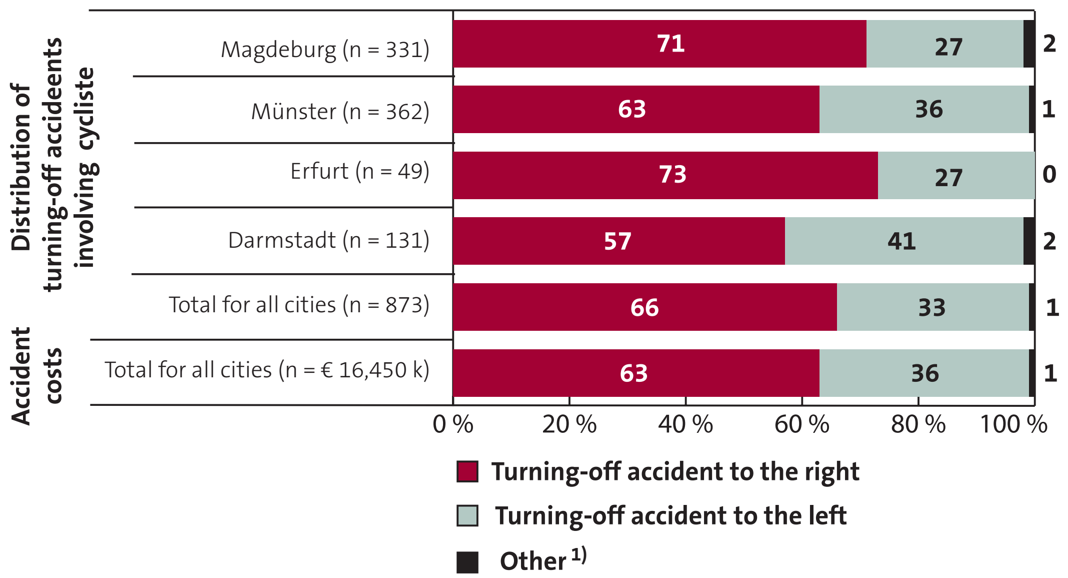
The driver of the motor vehicle was primarily responsible for accidents involving a cyclist in 91 % of the cases and solely responsible in 77 % of the cases. Most of the motor vehicles involved in these accidents were cars (86 %). A further 11 % were trucks or delivery vehicles. These figures matched the distribution of vehicle types in the traffic counts carried out in the project. However, the accidents were more serious when they involved a truck or delivery vehicle.

In the great majority of turning-off accidents involving cyclists in which the driver was at least partially responsible for the accident (in 95 % of the cases), the accident cause was recorded as a turning-off error. Driving under the influence of alcohol or drugs was a relatively insignificant factor (1 %).

The most common causes of accidents caused by the cyclists involved were „illegal use of a carriageway or lane or other parts of the road" (e.g. cycling against the flow of the traffic illegally or using the sidewalk), „other cycling errors" and „failure to observe the rules, as required by a police officer or at traffic lights" (generally this was a failure to observe a red light). Inadequate lighting was recorded in 7 % of the accidents for which the cyclist was at least partially responsible. That corresponds to 9 % of all accidents that occurred in darkness or poor light. Almost 7 % of cyclists involved in accidents were under the influence of alcohol or drugs.

The ratio of turning-off accidents where the driver was turning off to the right (to the near side) to those where the driver was turning off to the left (to the off side) varied from one city to another. Taking all four cities together, accidents involving motor vehicles turning off to the right accounted for around two-thirds of the turning-off accidents involving cyclists (figure 4). Accidents involving motor vehicles turning off to the left were generally more serious. This can also be attributed to the higher speeds of vehicles turning off to the left.

The analysis of the demographic attributes of those involved in turning-off accidents invol-



Deviations from 100 % are the result of rounding

1) ˝Other" comprises accident types 25 (priority road bends at intersection), 26 (vehicle turning off obliged to give way) and 29 (other turning-off accidents).

Figure 4:
Distribution of turning-off accidents involving cyclists and accident costs by turning-off maneuver and city (2007-2009)

ving cyclists revealed no significant difference in the mileage-based accident risk of male and female cyclists. The mileage-based accident risk of the female drivers involved was somewhat higher than that of the male drivers. Whereas women in relatively small cities account for around 35 % of car mileage, in the cities included in the study they were involved in turning-off accidents involving cyclists disproportionately frequently (in 39 % of the cases).

The analyses of the ages of those involved in the accidents revealed a markedly increased mileage-based accident risk for turning-off accidents involving cyclists for cyclists in the 25-34 and 21-24 age groups. 18-20-year-old drivers and drivers over 65 years of age had a particularly high mileage-based accident risk.

Taking all the cities together, it was found that the times at which the accidents occurred and the circumstances in which they occurred (weather and light conditions) basically correspond with the volumes of cycling and motor vehicle traffic at these times and under these circumstances.

4 Influence of the infrastructure on accidents and conflicts

4.1 Distribution of turning-off accidents to the right and left

Almost two-thirds (63 %) of all turning-off accidents involving cyclists involved the driver turning to the right, in other words the near side (figure 5). On the other hand, it was particularly striking that a very high proportion of turning-off accidents to the left occurred on roads shared by cyclists in mixed traffic (i.e. without a cycle lane or path). The relevant percentages were 56 % on roads with traffic lights and 68 %

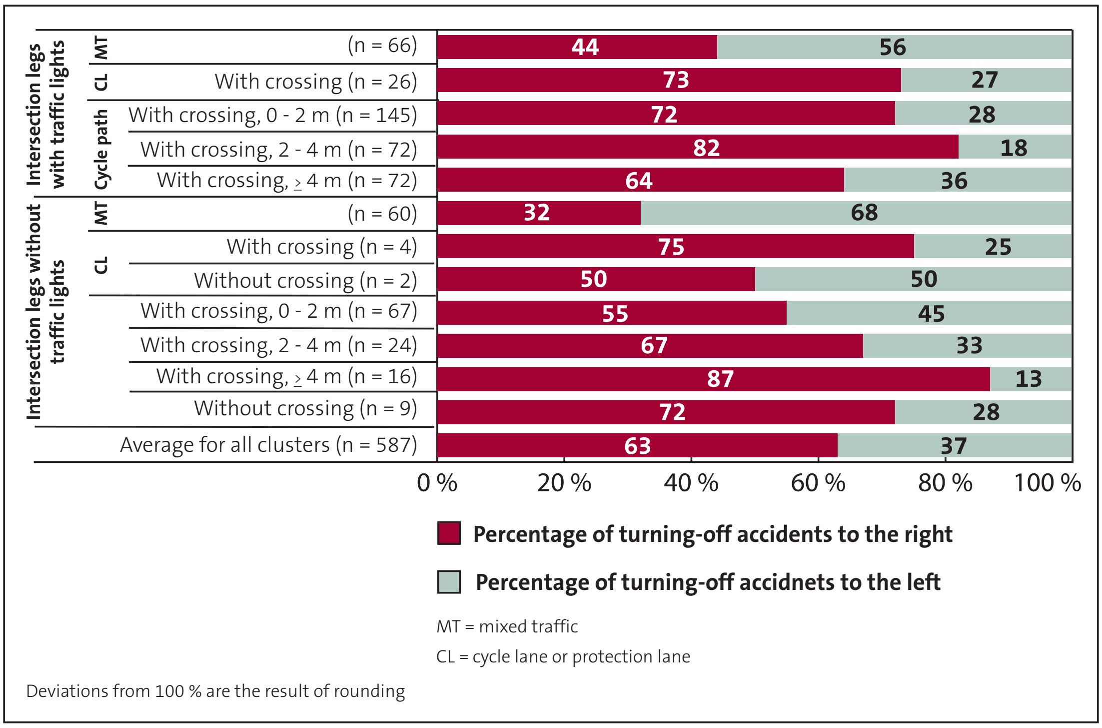


Figure 5:
Turning-off accidents to the right and left involving cyclists by cluster (2007-2009)

on roads without traffic lights. It was also noticeable that, in particular on intersection legs with traffic lights and cycle lanes, as well as on cycle paths with traffic lights and crossings with a short to moderate set-back distance, the proportion of turning-off accidents to the left was significantly lower than the average across all clusters. This was not the case on comparable intersection legs without traffic lights. The low proportion of turning-off accidents to the left on cycle paths without traffic lights that had crossings with a considerable set-back distance was not representative on account of the low number of cases.

4.2 Turning-off accidents to the right

The following infrastructure configurations were particularly significant with regard to turning-off accidents to the right: cycle paths with traffic lights and crossings with a moderate set-back distance (2-4 m) and cycle paths without traffic lights and with crossings with a considerable set-back distance (> 4 m). Intersection legs with traffic lights and cycle lanes or „protection lanes" were also found to be significant accident indicators.

The cluster with most significance for accidents was **cycle paths with traffic lights and a crossing with a moderate set-back distance of 2 to 4 meters.** This is a relatively common configuration of the infrastructure for cyclists on the main cycling routes and on the main roads of the cities included in the study. This cluster had high numbers of accidents, accident densities and accident frequencies as well as a high accident risk based on the volume of cycling traffic. The cluster also had high accident cost rates. In spite of the significance of these accident indicators, behavior in violation of the rules was not found to occur particularly frequently. In the microscopic analysis for turning-off accidents to the right for this cluster, cyclists were not found to be either cycling against the flow of the traffic or using the wrong part of the infrastructure particularly frequently.

In the observations of behavior, it was found that drivers most often looked over their shoulder and most often braked before turning off at cycle crossings with a moderate set-back distance. This cluster thus stood out particularly in the accident statistics in spite of the fact that drivers exercised particular care when driving. The very frequent obstructions to visi-

Figure 6:
Cycle path with traffic lights and a crossing with a moderate set-back distance

Figure 7:
Cycle path without traffic lights and a crossing with a considerable set-back distance

bility found in the on-site inspections (64 % of the intersection legs in this cluster) may have made accidents more likely in this infrastructure configuration.

Another cluster that stood out in the accident statistics was **cycle paths without traffic lights and with a crossing with a considerable setback distance (> 4 m).** This is a relatively rare configuration. Overall, the intersection legs in this cluster had low numbers of accidents, accident densities and accident cost densities. For turning-off accidents to the right, however, they had the highest accident risk for both cyclists and motor vehicles turning off to the right (highest accident rates). The accident cost rates were also found to be the highest overall. The traffic counts carried out revealed that, compared to the number of accidents occurring at roads in this cluster, the traffic volumes of both motor vehicles and cyclists were relatively low.

A cyclist and a motor vehicle that is turning off do not often come across each other, and it is thus an unexpected occurrence to those involved. The driver may very well not consider the possibility of there being a cyclist on roads in

Figure 8:
Intersection with traffic lights and a cycle lane

this cluster, and this is reflected in the high accident risk for both road users. Above all, the very high number of obstructions to visibility (they were found at 80 % of the roads in this cluster in the on-site inspections) made accidents more likely, as did the increased number of cyclists cycling against the flow of the traffic in this cluster (in both the traffic counts and the accidents investigated).

Intersection legs with traffic lights and cycle lanes or protection lanes were also found to be significant accident indicators. This cluster had very high accident frequencies and accident cost frequencies. There were a total of only 42 such intersection legs in the cities included in the study, making them relatively rare. However, the number of accidents and the accident costs of turning-off accidents to the right on these roads were disproportionately high. This was reflected in high accident densities and accident cost densities.

In contrast, the accident risk for cyclists and motor vehicles turning off to the right was very low (very low accident rates). The corresponding accident cost rates were also very low. The relatively high accident (cost) densities and accident (cost) frequencies are very much put into perspective by the high volumes of cycling and motor vehicle traffic in this cluster. The microscopic accident analysis revealed that the cyclists in all of the turning-off accidents to the right in this cluster used the cycle crossing provided and were riding in the same direction as the flow of traffic (i.e. not in the wrong direction). The high accident frequencies and densities can thus not be explained by the cyclists violating the rules.

Due to the low number of cases (the relative rarity of this road infrastructure configuration in the cities included in the study), the interpretation of this data cannot be considered to be

Figure 9:
Intersection without traffic lights and with cyclists sharing the road in mixed traffic

totally reliable. This road infrastructure configuration should be examined in more detail in the course of further analyses involving larger numbers of cases.

4.3 Turning-off accidents to the left

Roads shared by cyclists and motor vehicles in mixed traffic at intersections without traffic lights featured strongly in the accident statistics for turning-off accidents to the left. In addition, intersection legs with traffic lights and cycle lanes or protection lanes were also accident indicators for turning-off accidents to the left involving cyclists.

Roads shared by cyclists and motor vehicles in mixed traffic at intersections without traffic lights represented a particularly high accident risk for cyclists and motor vehicles turning off to the left. Since this configuration was by some distance the most common one found in the cities included in the study, the high number of turning-off accidents to the left is put into perspective by low accident frequencies and accident cost frequencies. The accident densities and accident cost densities are also very low. Accidents on intersection legs in this configuration are thus a very rare occurrence.

In contrast, however, this cluster has clearly the highest accident risk for both cyclists and motor vehicles for turning-off accidents to the left (highest accident rates) as well as the highest accident cost rates. This can be explained by the fact that motor vehicles turning off to the left and cyclists rarely come across each other in this configuration (due to low traffic volumes). Consequently, the driver may not be considering the possibility of there being a cyclist and may fail to see the cyclist on the road. When the cyclists use parts of the infrastructure in a way that the driver does not expect or that violates the rules, or if they cycle against the flow of the traffic or are allowed to use the sidewalk, this is even more likely. One in four cyclists in this road infrastructure configuration were found to be riding against the flow of the traffic in the traffic counts, and over one in four were using the space to the side of the road rather than the carriageway. However, neither cyclists cycling against the flow of the traffic nor the use of the wrong parts of the infrastructure were recorded as a cause of turning-off accidents to the left particularly often in this cluster.

However, the fact that cyclists are allowed to use the sidewalk in some cases does have an impact on the results of the accident analysis, although this could not be ascertained beyond doubt due to the fact that the data was incomplete. The background to this is that, on roads where this rule applies, the cyclist was not violating the rules by cycling on the sidewalk, and use of the wrong parts of the infrastructure could therefore not be recorded as the cause in the accident data. Nevertheless, a driver in this road infrastructure configuration may not expect there to be a cyclist on the sidewalk.

As with turning-off accidents to the right, **intersection legs with traffic lights and cycle lanes or protection lanes there** were significant accident indicators for turning-off accidents to the left involving cyclists. There was a similar picture in terms of these accident indicators in both cases. In the microscopic accident analysis, it was found that the cyclist in all of the turning-off accidents to the left investigated in this cluster was cycling in the same direction as the flow of the traffic (i.e. not in the wrong direction). In one of every four accidents, the cyclist was using the pedestrian crossing instead of the cycle crossing. Due to the small number of cases, no conclusive interpretation of the macroscopic accident indicators could be made for turning-off accidents to the left either. This road infrastructure configuration should therefore be investigated in more detail with regard to turning-off accidents to the left in the course of further analyses involving larger numbers of cases.

4.4 Other infrastructure-related influences on accidents

It was found in the accident analyses that, when the cyclists were cycling **against the flow of the traffic and using parts of the infrastructure in ways that were unexpected by the drivers,** this resulted in an increased number of turning-off accidents involving cyclists. Particularly when cyclists were sharing the road in mixed traffic or using cycle paths with crossings with a considerable set-back distance, cyclists did these things particularly often, and they occurred disproportionately frequently in the circumstances involved in accidents. It is problematic that drivers may not expect to come across cyclists who are not using the cycling infrastructure that is evidently provided. This may also be a sidewalk on which cycling is allowed. Consequently, it is particularly important to make it clear to all road users what part of the infrastructure cyclists are supposed to use and, wherever possible, not to allow cyclists to use the sidewalk.

It was particularly striking that a very high proportion of turning-off accidents to the left occurred on roads shared by cyclists in mixed traffic: 56 % on intersection legs with traffic lights and 68 % on intersection legs without traffic lights. In addition, it was revealed that, particularly when there were traffic lights, cyclists riding against the flow of the traffic were

Table 2:
Obstructions to visibility on inspected intersection legs with a conspicuous number of turning-off accidents to the right

Cluster (cycle paths only)		Inspected intersection legs with turning-off accidents to the right	Of which intersection legs with obstructions to visibility	Rate [%]
Cycle paths at intersections with traffic lights	With crossing, 0 - 2 m	38	11	29 %
	With crossing, 2 - 4 m	14	9	64 %
	With crossing, ≥ 4	17	10	59 %
Cycle paths at intersections without traffic lights	With crossing, 0- 2 m	13	1	8 %
	With crossing, 2 - 4 m	2	1	50 %
	With crossing, ≥ 4	5	4	80 %
	Without crossing	1	1	100 %
Total		**90**	**37**	**41 %**

involved in turning-off accidents to the left particularly frequently.

Local **obstructions to visibility** were revealed to be a significant problem on intersection legs with cycle paths. These are found, above all, on intersection legs that have cycle paths and cycle crossings with a moderate or considerable set-back distance (table 2). In turning-off maneuvers to the right, in particular, it is not always possible at such intersections for drivers to get a clear view of a cyclist when they look over their shoulder as they turn.

The effect of red cycle crossings on road safety could not be investigated due to the fact that there were not enough cases.

In the on-site inspections, a variety of other factors that could have had an influence were identified on those intersection legs that featured strongly in the accident statistics, such as downhill stretches for cyclists, drivers turning off to the right very fast (large turning radiuses) or large intersections where there was a lack of clarity.

5 Behavior and situations on the roads

5.1 Situation-related influencing factors

In addition to the infrastructural influencing factors, a number of other factors were identified that can have an influence on conflicts and accidents.

At intersections with traffic lights, the **signal phase** is decisive for the driver and cyclist. If both road users start off when the lights change to green, the probability of a conflict between the driver and cyclist is very low. The probability of a conflict is trebled if the driver and cyclist reach the intersection at the same time when the traffic lights are on green (i.e. without stopping first). The conflict rate was found to increase by a factor of nine if the driver started off when the light turned green and the cyclist came from behind and cycled through without stopping. In this constellation, the cyclist approaches at speed from behind while the driver is driving very slowly. This frequently results in conflicts.

Situations likely to result in accidents were also observed in **lines of vehicles turning off.** When drivers were in a line of vehicles that were turning off and thus had to adjust to the speed of the vehicle in front of them rather than choosing their own speed, the conflict rate was six times as high as for drivers who were not in a line of vehicles. In this situation the drivers appear to focus on the traffic in front of them and either fail to notice cyclists who are approaching or make an incorrect assessment of their speed.

This finding is also reflected in the **visual contact between drivers and cyclists.** In con-

Figure 10:
Increased probability of conflict when both the driver and cyclist reach the intersection at a green light

trast to the on-site inspection, in which local obstructions to visibility were investigated (e.g. parked cars), in this case it was investigated whether a cyclist crossing the road was directly in the field of view of the driver who was turning off. When this was the case, the conflict rates observed were very low. On the other hand, if the cyclist in the approach phase was always behind or at most level with the motor vehicle and the driver had to look over his or her shoulder to notice the cyclist's presence, the conflict rate increased by a factor of eight.

5.2 Road users' attitudes and knowledge of the rules

In addition to the observations, a representative telephone survey was conducted in the four cities included in the study to investigate the attitudes of road users and their knowledge of and adherence to the rules. The conflict situation mentioned most often by the respondents in the survey was that between a motor vehicle turning off to the right and a cyclist cycling straight ahead. They were all able to describe the rules applicable in this situation correctly. However, there were gaps in their knowledge with regard to **whether it is mandatory to use cycling facilities.** 85 % of the respondents stated that it was mandatory to use a cycling facility, if present, according to the German road traffic regulations (StVO). In fact it is only mandatory to use it if it is signalized by a corresponding traffic sign. There were no significant differences between drivers and cyclists. There were only significant differences between the cities when the respondents were asked about the heedfulness of and consideration shown by road users. In Münster, drivers were perceived particularly positively, and cyclists were regarded as being comparatively careless and as showing less consideration for other road users. Drivers were also perceived to follow the rules better than cyclists in all of the cities included in the study.

5.3 Violations of the rules

Various rule violations by cyclists were also documented in the behavioral observation phase. Thus, 17 % of all cyclists were riding in the **wrong direction** and 13 % did **not use the cycling facility provided** to cross the intersection when cycling straight ahead. Instead, they crossed to the right of it in line with the sidewalk. The latter scenario was observed significantly more frequently in conflicts (24 %). It is to be assumed that the drivers would have expected the cyclists to be using the cycling facility in this case and that they were surprised to see them elsewhere. There is also a problem in that the driver generally cannot know whether a cycle path is a two-way path. When turning off, the driver therefore generally has to take into account the fact that there may be cyclists coming from both directions. Two-way cycle paths should nevertheless always be marked as such (e.g. with arrows and pictograms on the cycle crossing) so that all road users know that they can expect cyclists to be coming from both directions.

Red light violations by cyclists were very rarely observed, but they are represented dispropor-

Figure 11:
Cycling against the flow of the traffic in violation of the rules

tionately frequently in the accident statistics. Some of the cyclists demonstrated clearly defensive behavior (ceasing to pedal, braking and getting out of the way, for example) even when they had the right of way to cross.

One in five drivers were observed not to look over their shoulder when there was at least one cyclist in the immediate vicinity wanting to cross the side road at the intersection. In the cases of conflict observed, one in three drivers failed to look over their shoulder, thus significantly increasing the probability of coming into conflict with a cyclist crossing the side road.

6 Level of importance of cycling and road safety

The cities selected for the project varied in terms of the level of importance of cycling on their roads and the modal share accounted for by cycling. They were selected because of the range of levels of importance and modal shares of cycling they offered.

The results of an investigation carried out by the ADFC in 2005 [6] were used to subjectively assess the level of importance of cycling in the cities. In addition, the cities' planning documents were systematically examined to identify statements about cycling, and relevant Internet research was carried out. The subjective importance of cycling was highest in Münster, followed by Magdeburg, Darmstadt and Erfurt. However, there were only slight differences between the last three cities in terms of the importance of cycling.

The analysis of the macroscopic accident indicators showed a connection between the frequency of accidents and conflicts, on the one hand, and the level of importance of cycling in the cities and the modal share accounted for by cycling, on the other. The more important cycling was found to be in these cities, and the higher the modal share accounted for by cycling, the higher was the level of road safety with regard to the accident or conflict situation investigated (i.e. where a motor vehicle is turning off a road and a cyclist is cycling straight ahead).

In the telephone survey and behavioral observations, it was ascertained that the adherence to the rules and heedfulness of drivers in Münster was significantly higher than in the other cities investigated. In addition, a higher level of importance of cycling and a larger modal share of cycling in the cities were reflected in a higher level of satisfaction among cyclists, lower accident cost rates in relation to the number of cyclists cycling straight ahead and lower conflict rates (table 3).

Table 3:
Level of importance of cycling, modal share of cycling and road safety for motor vehicles turning off the road and cyclists cycling straight ahead

City	Ranking by level of importance of cycling	Modal share of cycling	Conflict rate	UCR (cyc.)*
Münster	1	37.6 %	5.8 %	27.6
Magdeburg	2	14.6 %	11.5 %	33.9
Darmstadt	3	14.4 %	13.9 %	39.1
Erfurt	4	8.8 %	13.2 %	72.1

* Accident cost rate (accident costs in euros per 1,000 cyclists cycling straight ahead)

Image campaigns for cycling and the increase in the modal share of cycling generally associated with these can improve road safety in two respects. On the one hand, conflicts are reduced when significant numbers of cyclists cross at an intersection. On the other hand, when there is a high volume of cycling traffic, drivers become sensitive to this, and higher levels of consideration and heedfulness can be expected from them.

7 Summary and recommendations

7.1 Infrastructure

Cycle paths with crossings with a moderate or considerable set-back distance were revealed to be a particularly significant factor in relation to turning-off accidents in which motor vehicles turn off to the right. In these cases, there are very often local obstructions to visibility by the road that make visual contact between the driver and cyclist difficult or even prevent it.

Roads shared by cyclists and motor vehicles in mixed traffic at intersections without traffic lights have significant accident indicators for turning-off accidents in which motor vehicles turn off to the left. Although turning-off accidents to the left are very rare in this road infrastructure configuration, a very high accident risk was found in this configuration for cyclists cycling straight ahead and motor vehicles turning off to the left. One explanation for this is that motor vehicles turning off to the left and cyclists rarely come across each other in this road infrastructure configuration. Consequently, the driver may not consider the possibility of there being a cyclist and may fail to see the cyclist. When cyclists use parts of the infrastructure in a way that the driver does not expect or that violates the rules, or if they cycle against the flow of the traffic in this road configuration (and possibly also if they are allowed to use the sidewalk), the driver is even less likely to see them.

As far as the road infrastructure is concerned, the following recommendations can be made with regard to the design of intersections in built-up areas:

- Obstructions to visibility around the intersection must be rigorously removed. These include vegetation, installations, advertising and parked vehicles.
- Corresponding fields of view must also be kept free to allow drivers to look over their shoulders.
- It is recommended in the interests of improving visibility that cyclists should either be on the road with the motor vehicles or on a cycle lane or cycle path that is close to the road.
- In order to bring them to drivers‘ attention, cycle paths and lanes and cycle crossings, in particular, must be designed in such as a way as to make them stand out. As a general rule, crossings for cyclists should be marked out. In addition, as recommended in ERA 2010, the surface should be red at locations where there is a significant risk of accidents.
- Cyclists must be given clear, easily understood guidance at the intersection and on the approach to it. Above all, this means:
  - They should not be allowed to cycle on the sidewalk.
  - All of the measures specified in ERA 2010 should be implemented to prevent cyclists from cycling against the flow of the traffic and using the wrong parts of the infrastructure.
- Cycle paths must be designed and maintained with safety in mind even where it is not mandatory to use them. If appropriate, they must be upgraded or removed.
- It is recommended that drivers turning off the road and cyclists cycling ahead should

have their own dedicated traffic lights at the intersection, particularly when:
- The volume of traffic turning off is high.
- The drivers turning off drive fast (large turning radiuses).
- The cyclists are cycling fast (e.g. on downhill sections).
- The intersections are complex or unclear.
- There are obstacles to visibility that cannot be removed (e.g. projecting parts of buildings).

7.2 Behavior on the roads

It is necessary for all road users to adhere to the rules of the road if road safety is to be improved. By means of suitable measures and campaigns to promote road safety, and when they are learning to drive, road users must receive the following safety-related information:

Drivers:

- It is essential to look over your shoulder when turning off the road. Both when people are learning to drive and in campaigns, it must be pointed out that this reduces accidents.
- When turning off the road, drivers must always be prepared for cyclists coming from both directions.
- In addition, when turning off to the left, they must also be prepared for cyclists coming towards them on the road.

Cyclists:

- Targeted measures should be introduced to prevent cyclists from using the sidewalk. This will reduce the likelihood of them becoming involved in a conflict with a motor vehicle. The same applies to illegally cycling against the flow of the traffic. Cyclists must be requested to use the cycling facilities provided. If there is no separate cycling facility, cyclists should use the road instead of the sidewalk[3].
- Without depriving cyclists of their right of way, efforts must also be made to make them more heedful. Due to circumstances at particular locations (e.g. parked cars, verges with vegetation, structures, etc.) or the type of vehicle driven (e.g. a truck), in some cases it is difficult for drivers to see a cyclist approaching from behind in time. If cyclists can be made more heedful and their knowledge of critical situations improved, the number of conflicts and thus also accidents that occur can be reduced.

General:

- Drivers and cyclists must be made aware of the problems in particularly critical turning-off situations. These include, above all, situations in which the cyclist is approaching from behind and is not in the driver‘s field of view as well as situations in which the driver is in a line of vehicles that are turning off.
- Both drivers and cyclists must be made aware that cycling facilities are mandatory if there is no corresponding traffic sign. Most respondents in the survey did not know this.

7.3 Driver assistance systems

- When drivers turn off a road in certain situations, critical conflicts can occur between motor vehicles and cyclists that can lead to an accident (e.g. when a motor vehicle and cyclist reach an intersection at the same time at a green light). The following recommendations are made for the development of driver assistance systems to help drivers in dangerous turning-off situations involving cyclists:
- It is necessary to detect cyclists approaching from behind at comparatively high speeds

[3] The use of the sidewalk should be reserved for children under the age of 10, as stipulated in the German road traffic regulations (see StVO section 2 paragraph).

when the motor vehicle itself is often turning off at a relatively low speed.

- The system should also be able to detect cyclists cycling against the flow of the traffic and when the motor vehicle is turning off to the left.
- The systems should serve to increase awareness.

8 Concluding remarks

In summary, it is important to state that turning-off maneuvers require all road users to exercise caution and show consideration for other road users. If they show consideration for each other and are more attentive in these situations, conflicts and accidents can be avoided, and road safety at intersections or junctions can be improved.

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