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## Yielding behaviour and interaction at bicycle crossings

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Hydén et al

## Yielding behaviour and interaction at bicycle crossings

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**ABSTRACT**

The main purpose of this study was to learn more about how bicyclists and motor vehicle drivers in some Swedish cities interact at intersections and how the yielding rules, different intersection designs, vehicle flows and speed affect the behaviour.

Field studies were performed at 25 crossings for six hours each. Cycle crossings on links, at three- and four-armed intersections as well as at roundabouts were studied.

Preliminary results show that yielding rules are not enough to make road users behave as intended; even when there are yielding signs and markings before the bicycle crossing, 30% of the motor vehicle drivers do not yield to bicyclists. Fewer yield to bicyclists when motor vehicle speed is higher, when motor vehicle flow is larger and when bicycle flow is smaller. Speeds below 30 km/h seem to produce quite favourable conditions for an interaction with a high degree of equity, efficiency and safety for both road users no matter whether car drivers have to yield according to the rules or not. Motor vehicle drivers are most likely to give way to bicyclists when the bicycle crossing is next to a roundabout and least likely to give way when it is situated on a link.

The conclusion is that there is a certain amount of drivers that do not obey the yielding rules and presumably rely on their larger mass and better protection. It is therefore very important that the road design allows for active interaction between the road user groups to get a more equal situation between motor vehicle drivers and bicyclists as well as safe and secure bicycle crossings. Speed is obviously the key issue.

## **YIELDING BEHAVIOUR AND INTERACTION AT BICYCLE CROSSINGS**

by Lisa Jonsson, Christer Hydén and Åse Svensson

### **INTRODUCTION**

Cyclists are vulnerable road users in many senses. Compared with motorised road users they are at higher risk for accidents, they face often more serious consequences of accidents, they are less visible in traffic, their moving energy is smaller, and they are less visible and strong in the general debate about traffic. All these things are problems that have to be dealt with seriously, not the least because of the traffic policy taken by the Swedish Parliament. It says, among other things, that the system should be based on equity between e.g. different types of road users. One can easily see that there are huge challenges linked with this part of the policy.

A well functioning interplay between motorists and bicyclists is the most important prerequisite for securing the welfare of bicyclists. Based on the problem definition above, a well functioning interplay means that this interplay should not produce the kind of drawbacks mentioned. It is important to understand that the interplay have two parties who both of them have a shared responsibility for the success of the interplay. A cyclist is a “road user with a vehicle” just like a car driver, and therefore the same traffic rules are valid for both of them. It is also important to understand that we are dealing with an **interplay**, i.e. the two play together. So if one change his behaviour the other one most likely will change his behaviour and adapt to the new situation. This has e.g. been clearly demonstrated when speed reducing humps have been put in front of a pedestrian/bicycle crossing. The result was a higher compliance with yielding rules by the car drivers, **and** less attentiveness by the pedestrians/cyclists (Towliat 2002).

At the same time as the same rules apply to both car drivers and cyclists there is a big difference regarding the type of behaviour demonstrated by the two groups. Car drivers for instance do often speed – more than 50% of all driving in Sweden is done with speeds above the speed limit. Speeding is rarely the case with cyclists. In stead their “freedom” is clearly demonstrated e.g. in their route choice. In a study of cyclist behaviour at roundabouts it was found that cyclist used seven different ways of passing the round-about in one single relation. Most of these route-choices were not in compliance with the rules. (Hydén, Várhelyi, Odelid 1995)

### **AIM**

The objective of this study is to support the Swedish National Road Administration in their work with traffic rules and road design recommendations concerning bicyclists. The main topic is the Swedish yielding rules for vehicles versus bicyclists. Today a lot of road users find these rules unclear because they depend on where and in what situation the road users are.

## METHODS USED

Observational studies were made at pedestrian and bicycle crossings at 38 locations in 6 different cities. Each site was studied during six hours spread out over the day. The studies focussed on **interaction** between a car driver and a pedestrian or bicyclist, i.e. only situations were one or both of the two road users involved had to adjust speed or direction because of the other road user. We also restricted the study to include situations where the pedestrian or bicyclist appeared individually to the crossing. We also restricted the study to include car drivers that had a time gap to a car in front of at least 2 seconds. These restrictions were made in order to be able only to compare the same type of interactions without too many disturbances. Interactions were typologised as described in table 1 below.

TABLE 1 The different types of interactional behaviours by the three road user groups

<b>Car driver</b>	<b>Pedestrian</b>	<b>Bicyclist</b>
Stops/ letting the ped/bic pass	Stops/ letting the car pass	Stops/letting the car pass
Adjusts/ letting the ped/bic pass	Stops 1m away/ letting the car pass	Stops 1m away/ letting the car pass
Continues	Adjusts/ letting the car pass	Adjusts/ letting the car pass
Adjusts/ does <b>not</b> let the ped/bic pass	Stops/goes first	Stops/goes first
Stops/ does <b>not</b> let the ped/bic pass	Stops 1m away/goes first	Stops 1m away/goes first
	Adjusts/goes first	Adjusts/goes first
	Continues unchanged	Continues unchanged
		Get off the bike

### Some clarifications

Each interaction is classified according to **one** car driver behaviour and **one** pedestrian or bicyclist behaviour. Stops mean that the road user is absolutely still, and that a bicycle rider at least has one foot on ground. Stops 1 meter away means that a pedestrian or bicyclist is stopping at least 1 meter from the curb side. The implication is that the pedestrian or bicyclist hereby wants to indicate for the car driver that he/she can wait till the car has passed. Adjusts means that the car driver, pedestrian or bicyclist adjust his/her speed or direction because of the on-coming car. Get off the bike refers to bicyclists who get off the bike before the crossing and then acts as a pedestrian when crossing. "Time advantage" is also noted. It refers to the expected time difference in arrival time to the meeting point. Time is positive if the car is expected to be before the pedestrian/bicyclist to the meeting point.

Volume counts were carried out, 5 minutes per hour, split on motor vehicles (called cars), pedestrians and bicyclists. Car speeds were measured with a radar gun, 20 minutes per location. Only "free vehicles" (time gap > 3 seconds) were included.

### Reliability

Six observers were employed for the project. They were trained during two days. During the last 45 minutes they were observing the same crossing. The result of this test was that they on average noted 15 car-pedestrian interactions with a standard variation of 2,2 and 12 car-bicyclist interactions with a standard variation of 1,9. On average the pedestrian passed before the car in 88% of the cases, with a standard variation of 7 %-units. In the bicyclist case the corresponding average was 52% with a standard variation of 21 %-units.

In all but the last case the variation was quite acceptable. The last case indicates clearly that the bicyclists' interactions are more difficult to record reliably. However, as the other parts of the test were ok, and the observers were part of an analysis of the differences, they were accepted and sent out on the mission.

### Choice of locations

Six cities were selected; Lund, Malmö, Katrineholm, Eskilstuna, Örebro and Karlstad. The cities represent different size and different bicycle use. The observers selected sites themselves. The criteria included design – there should be a well-defined and marked bicycle and/or pedestrian crossing - and volumes – at least one interaction per 10 minutes. The observers were also told to try and have a variation in volumes. There should be no signal-controls nor any stop-regulations.

The distribution of locations were as follows by table 2:

**TABLE 2 Distribution of variables (figures indicate the total number per category)**

Number		Between Inter-sections	Four armed Intersection	Round-about	Three armed Intersection
<b>Lanes</b>	<b>1/1</b>	10	11	5	6
	<b>½</b>	1	0	2	1
	<b>2/2</b>	1	0	1	
<b>Yield signs</b>		0	0	5	0
<b>No yield sign</b>		12	11	3	7
<b>Different colour (on the crossing)</b>		0	1	0	0
<b>Same colour</b>		12	10	8	7
<b>Raised crossing</b>		1	3	2	1
<b>Not raised</b>		11	8	6	6
<b>Marked bicycle crossing</b>		9	10	7	6
<b>No marking</b>		3	1	1	1
<b>Marked pedestrian crossing</b>		12	11	8	6
<b>No marked ped crossing</b>		0	0	0	1
<b>Median island</b>		2	2		3
<b>No island</b>		10	9	8	4
<b>Average Vehicle speeds</b>	<b>&lt;=30</b>	3	4	7	4
	<b>30-40</b>	4	4	1	2
	<b>40-50</b>	5	3	0	1
<b>City</b>	<b>Lund</b>	4	1	4	1
	<b>Malmö</b>	4	4	2	0
	<b>Örebro</b>	0	4	0	2
	<b>Eskilstuna</b>	1	0	2	1
	<b>Katrineholm</b>	3	1	0	0
	<b>Karlstad</b>	0	1	0	3

The volumes were as follows:

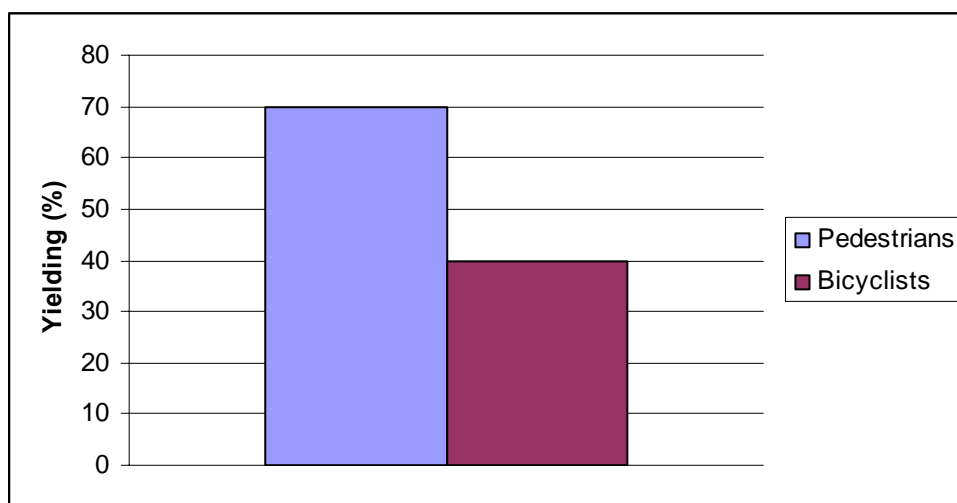
**TABLE 3 Distribution of car/ped/bicycle volumes on the 38 sites**

Average/10 minutes:	≤ 10	10-20	≥ 20
Number of sites, pedestrian flow	21	9	8
Number of sites, bicycle flow	16	11	11
Average/10 minutes	≤ 50	50-150	≥ 150
Number of sites, car flow	9	18	11

## RESULTS

### General

Totally 4707 interactions were recorded, 2823 interactions with bicyclists and 1884 with pedestrians. With great variations the yielding by car drivers towards pedestrians was on average 70% and towards bicyclists 40%.

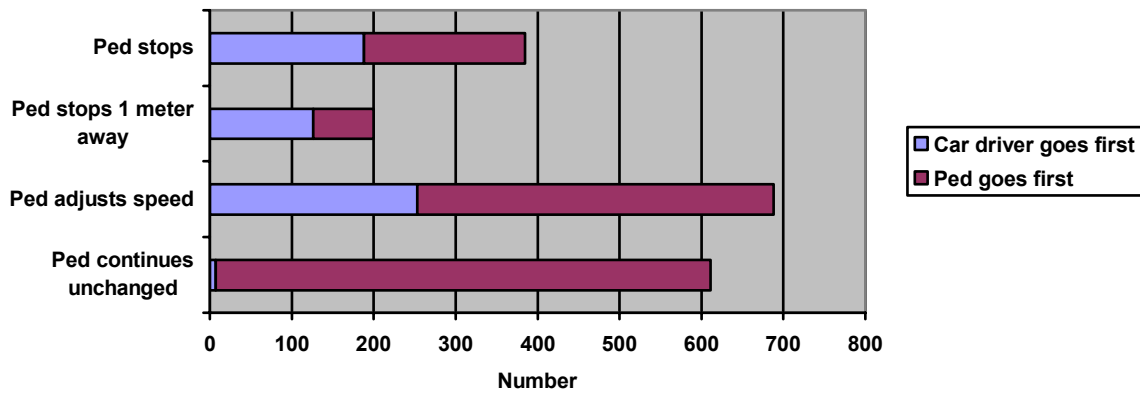


**FIGURE 1 Car driver yielding for pedestrians and cyclists**

It should be observed that according to the Swedish rules car drivers are obliged to yield for pedestrians at pedestrian crossings. Regarding bicyclists this is only the case in specific situations, like e.g. when a car has turned at an intersection, when a car is leaving a round-about or when there is a yield sign before the bicycle crossing. The figures in figure 1 indicates that there is a considerable yielding for bicyclists even though the rules do not state it. The decomposition of results later on in the paper will provide more information about this “phenomenon”.

**Pedestrian behaviour**

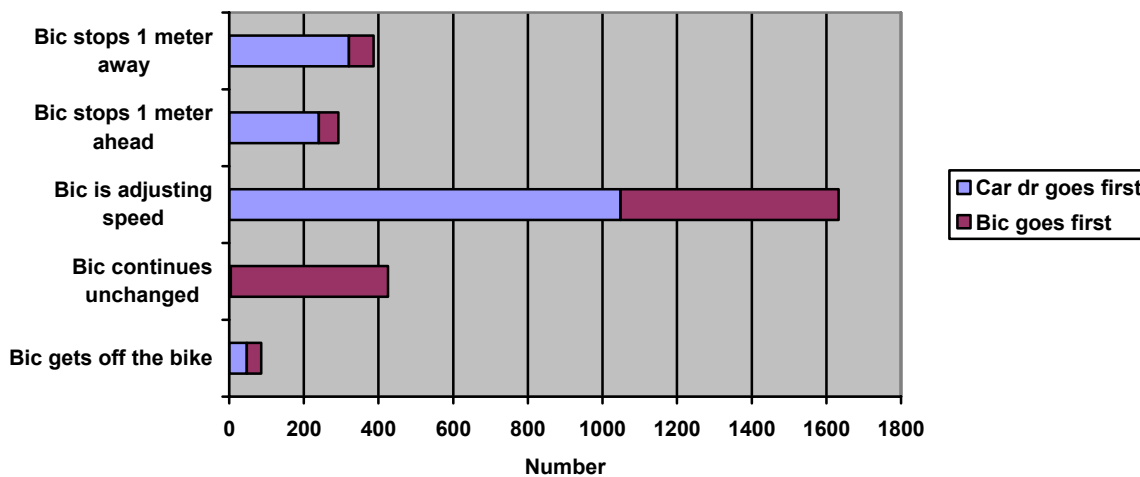
In a first decomposition we look at pedestrian behaviour and its implications on car driver behaviour, figure 2.



**FIGURE 2 Pedestrian behaviour**

Around one third of the pedestrians proceeded without changing speed or direction, a bit more than a third adjusted their speeds/direction and a bit less than a third stopped. Of those who stopped, ten percent did so one meter or more before the curb side, thereby indicating that the car could pass before them. This somehow indicates that there is a willingness also from (parts of) the pedestrians to take an active role in the interaction, not claiming their rights under all circumstances. Of those pedestrians who adjusted speed/direction car drivers yielded for 60% which is less compared with the total group of pedestrians. This also indicates an interactional element.

**Bicyclist behaviour**



**Figure 3 Bicyclist behaviour**

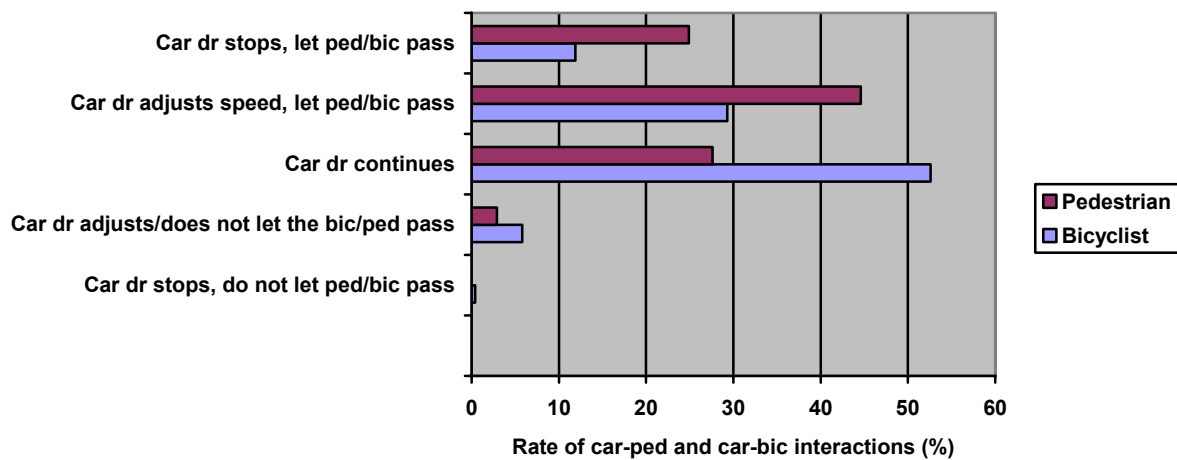
Compared with pedestrians there are many more bicyclists that adjust their speed/direction, almost 60%. Of these around 40% were passing before the car. Of those bicyclists who stopped, around one fourth, only 17% pass before the car. Fifteen percent of the bicyclists continue with unchanged speed. All these pass before the car.



The results show that there is a great deal of similarity in interactions between pedestrians and car drivers and between bicyclists and car drivers. The main difference is that the proportion of pedestrians who continue with unchanged speed/direction is twice as big as the proportion of bicyclists who do it. This may of course be due to the fact that pedestrians know that there is a rule making yielding for car drivers obligatory. It could also be due to the higher speed of bicyclists; they have to adjust the speed to be able to stop if necessary.

Generally, differences between pedestrians and bicyclists can depend on many factors, like speed, type of location, etc. Still, bearing in mind the clear difference in yielding rules the similarities indicate that pedestrians and bicyclists in large interact with car drivers in more or less the same way.

### Car driver behaviour



**FIGURE 4 Car drivers' behaviour towards pedestrians and bicyclists**

In figure 4 rates are presented and not numbers as in the earlier figures. When interacting with pedestrians the most common behaviour by car drivers is to adjust speed. This occurs in almost 50% of all interactions. This kind of behaviour is to be expected as car drivers according to the rule have to yield for pedestrians, i.e. a pending behaviour is quite appropriate. However, in spite of this yielding rule there is almost 30% of the drivers who continue with unchanged speed.

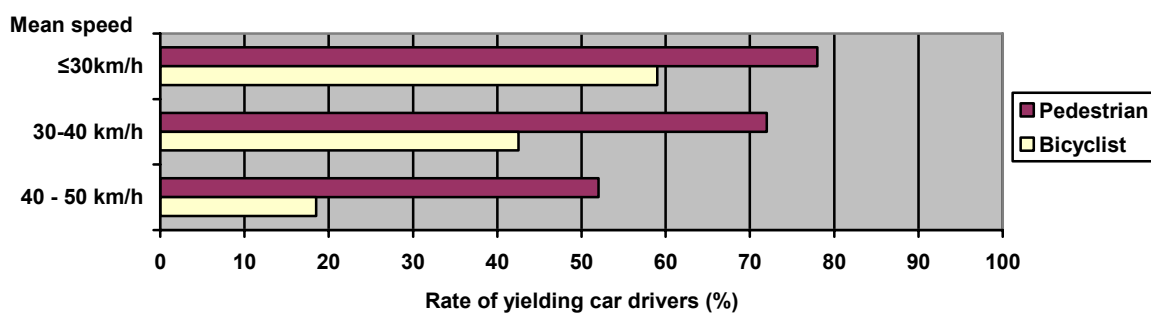
The main difference when one compares interactions with bicyclists and pedestrians is that car drivers stop less often and continue with unchanged speed more often in interactions with bicyclists (in 50% of the interactions compared with 30%). Still the differences are not very big, but primarily indicate that there are similarities in the way interactions work with the two groups of vulnerable road users.

In large the interactions work quite well. However, it is a very disturbing fact that almost 30% of the car drivers continue with unchanged speed in interactions with pedestrians. According to the rule it is quite clear that in interactions – as we have defined them – the car driver should **always** yield for the pedestrian. Based on our studies it is not quite clear what the consequences of this unclear situation will be from a safety point of view. The safety consequences were not possible to clarify within this study. However, there is good reason to anticipate some safety problems because of this. From the pedestrians' point of view most car

drivers yield for pedestrians. This easily becomes the habitual behaviour that pedestrians experience, and they may lose some of their attentiveness. At the same time when a car driver does not stop there is an obvious risk that the pedestrian is less attentive. Studies in Sweden, from the 1980-es and up till to-day indicate that the safety situation on Swedish pedestrian crossings is negative in the sense that the risk for pedestrians is higher on a crossing compared with a location without any facility for pedestrians (Ekman 1996, Thulin 20??). The main reason put forward is a behavioural modification by pedestrians, indicating that they are less attentive because of their rights on the crossing.

### The importance of speed on car drivers' interaction behaviour

Speed has not been measured directly on the car drivers observed, but only on a sample of cars passing the crossings. These speed levels have been split in three groups; average speeds  $\leq 30$  km/h, between 30-40 km/h and between 40-50 km/h.



**FIGURE 5** The influence of speeds on the rate of yielding car drivers (%)

Generally car drivers are yielding more often at locations with lower speed than at locations with higher speeds (Chi-square,  $p < 0,001$ ). In interactions with pedestrians the yielding increases from 50% to 80%, while in interactions with bicyclists the yielding increases from 20% to 60%. The difference in yielding if one compares pedestrians and bicyclists is becoming smaller the lower the speed. This clearly indicates the great importance of speed. In interactions with pedestrians there is a clear yielding rule as a basic guidance for the car drivers while at interactions with bicyclists there is no such (general) rule. In these latter interactions the interplay primarily has to be built on an agreement between the car driver and the bicyclist. Then obviously lower speeds create a situation where the “power” is more equally distributed between the two, and the bicyclist has a more fair chance to cross before the car driver. It should be observed though that this is partly assumptions based on interpretations of the observed behaviour at the crossing. In order to be able to draw more firm conclusions – and e.g. to be able to draw conclusions regarding the safety implications - it would be important both to make more detailed studies than ours and also to make interviews with the road users involved.

One more – partly hypothetical - remark is that with lower speeds the interaction becomes more active with both parties. At lower speeds there is more of a “first in – first out”-situation. This implies a more active participation by both road users involved. However, to draw more firm conclusions, again this should be studied more in detail. One thing is, however, quite clear, and that is that lower speeds produce less serious consequences of accidents.

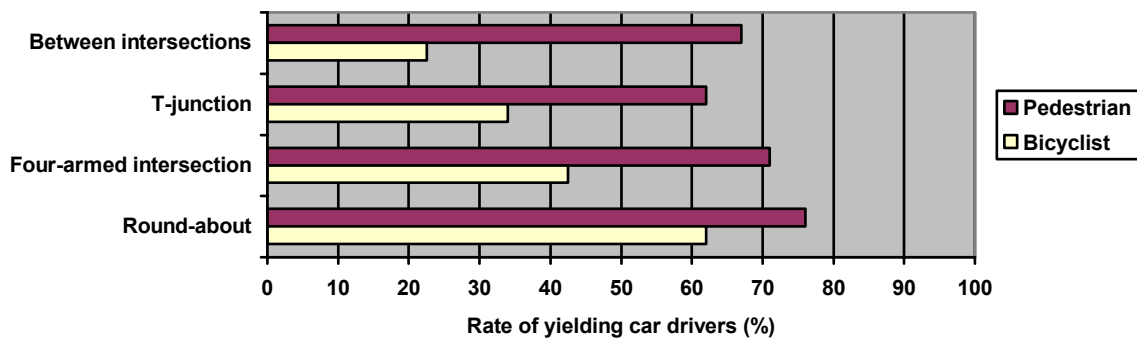
**The importance of volumes**

Volumes were categorised in three groups for each road user type; number of peds/bic: <10, 10-20, >20 per 10 minutes. Number of cars: <50, 50-150, >150 per 10 minutes. The relation between flows and yielding behaviour by car drivers was studied. No clear relationships were, however, found.

**Car driver behaviour at different types of locations**

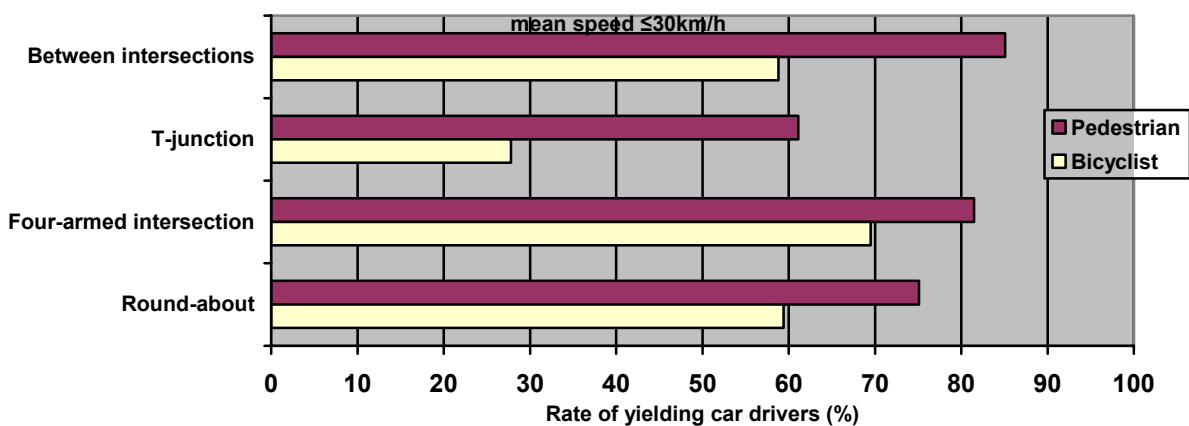
Car drivers behave differently towards bicyclists in the four different types of crossing locations. (Chi-square,  $p < 0,001$ ). Yielding is three times as common at round-abouts as it is on stretches between intersections. One reason for this can be that at round-abouts turning car drivers (when leaving the round-about) have to yield for bicyclists, while there is no such rule on stretches between intersections.

As can be seen in figure 6 there is no major difference in yielding behaviour towards pedestrians at any of the four types of crossing locations. It is in all cases between 60% and 80%. The lowest yielding rate is found at T-junctions (Significant difference with four-armed intersections,  $p < 0,05$ , and with round-abouts,  $p < 0,001$ , Chi-square)

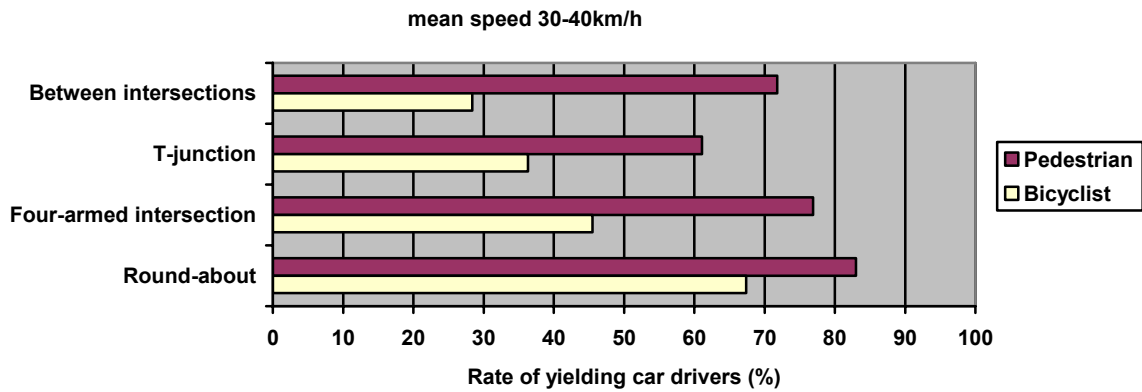


**FIGURE 6 Rate of yielding car drivers split on intersection type**

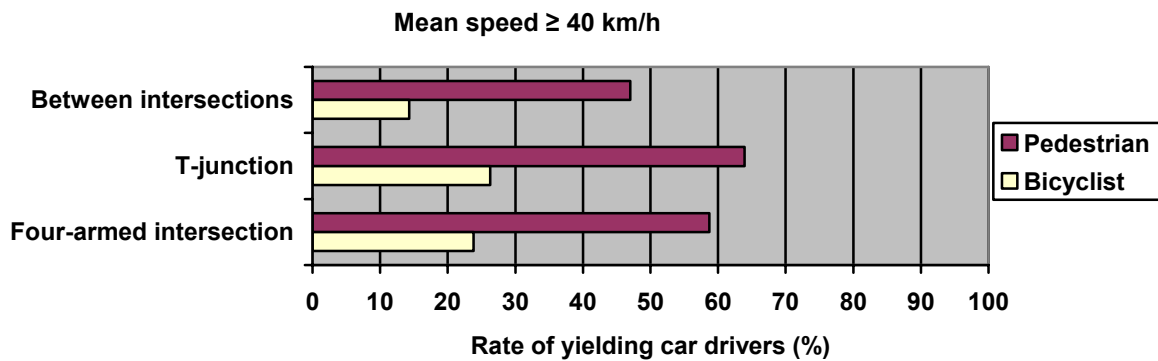
The difference in yielding behaviour between the four types of crossings may also be due to a co-variation between speeds and type of crossing. In order to find out if there exist such a co-variation the yielding behaviour is split on the three speed levels in figures 7 to 9 below.



**FIGURE 7 Rate of yielding car drivers split on intersection type, mean speed ≤ 30km/h**



**FIGURE 8** Rate of yielding car drivers split on intersection type, mean speed 30 – 40 km/h



**FIGURE 9** Rate of yielding car drivers split on intersection type, mean speed 40 - 50 km/h

The actual differences in speed are presented in table 3 below, in terms of 85-percentile speeds at the three different speed levels, for the four different types of crossings.

**TABLE 3** Average 85-percentile speeds

Crossing type/Speed class	≤ 30 km/h	30–40 km/h	≥ 40 km/h
<b>Between intersections</b>	30 km/h	43 km/h	52 km/h
<b>T-junction</b>	35 km/h	40 km/h	51 km/h
<b>Four-armed inters.</b>	29 km/h	40 km/h	52 km/h
<b>Round-about</b>	28 km/h	37 km/h	-

From figures 7 to 9 we can see that the yielding behaviour towards pedestrians is fairly the same for the different speed classes, the yielding rate is the lowest for T-junctions. Differences are though fairly small and, as before, the yielding rule applied on pedestrians seems to play the most important rule. The reason behind the lower rate at T-junctions is difficult to explain without more comprehensive studies. However, we know from other studies that car drivers' general compliance with the (right hand)-rule at T-junctions – when going straight through – is quite poor. This behaviour might be “imitated” and applied on the yielding towards pedestrians as well.

Regarding bicyclists figures 7 to 9 do not give any clear guidance. On stretches between intersections and at four-armed intersections the yielding rate increases with lower speeds, as expected. At T-junctions and roundabouts, however, the relation is the opposite. At roundabouts the differences are small and the rate is quite high generally. This may be due to a similar phenomenon as with pedestrians, namely that the yielding behaviour is strongly influenced by the rule. At roundabouts car drivers are obliged to yield for bicyclists in a large proportion of the interactions.

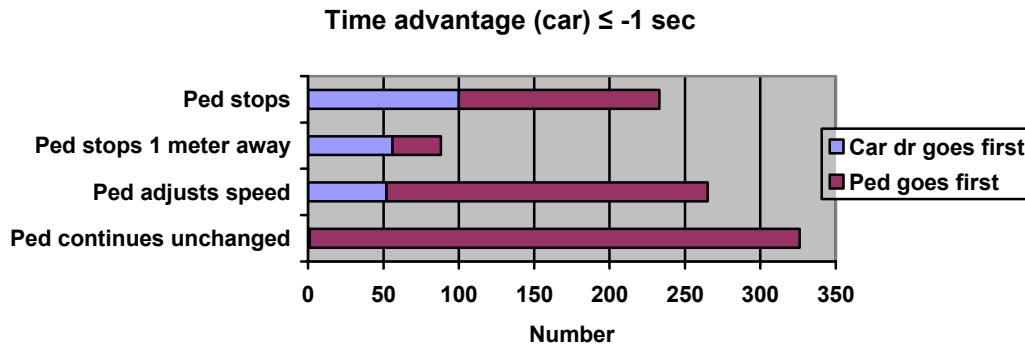
At T-junctions the yielding rate towards bicyclists is quite small generally, even at low speeds. Again, this is difficult to explain without more comprehensive studies. It is, however, likely that the generally poor yielding behaviour by car drivers at T-junctions may have been transferred to this situation as well.

### **Road user behaviour at different time advantages in the interactions**

Figures 10 to 15 show the yielding behaviour in relation to the time advantage by one of the two road users. The results indicate that there are no major differences in behaviour. For instance does the proportion of pedestrians who continue unchanged drop from 36% to 32% when the time margin turns from negative to positive for the pedestrian, i.e. when the advantage for the pedestrian is turned into an advantage for the car driver. The corresponding figures for bicyclists are a decrease from 17% to 10%.

The proportion of pedestrians who stop is decreasing from 35% to 26% with a decreasing time advantage for the pedestrians. Corresponding figures for bicyclists is a decrease from 37% to 16%. The proportion of pedestrians who adjust their speed is increasing from 28% to 42% with a decreasing time advantage for the pedestrians. Corresponding figures for bicyclists is a decrease from 46% to 74%.

These results do indicate some differences in behaviour based on the time advantage even though not very big. The most significant finding is that when the time advantage for pedestrians and cyclists is turned into a time advantage for the car drivers then the proportion of pedestrians and bicyclists who adjust their speed is increasing and the proportion that stop is decreasing. It is difficult to interpret why they do adjust their speed more often. The main reason may be that – when it is obvious for them – they can just adjust their speed so that they can pass just behind the car without being forced to stop. However, this is hard to understand without making more comprehensive studies. Interview studies would most probably produce more insight in the strategy of all road users. Besides there may also be some methodological problems. It is not unlikely that the manual observation of time advantages was too difficult. One reason for that might be that road users actually started on their interplay before the position where observers had a reasonable chance to make reliable observations. By using automatic video analysis – under development – we will hopefully be able to make more sophisticated, and complete, analysis of this interaction.

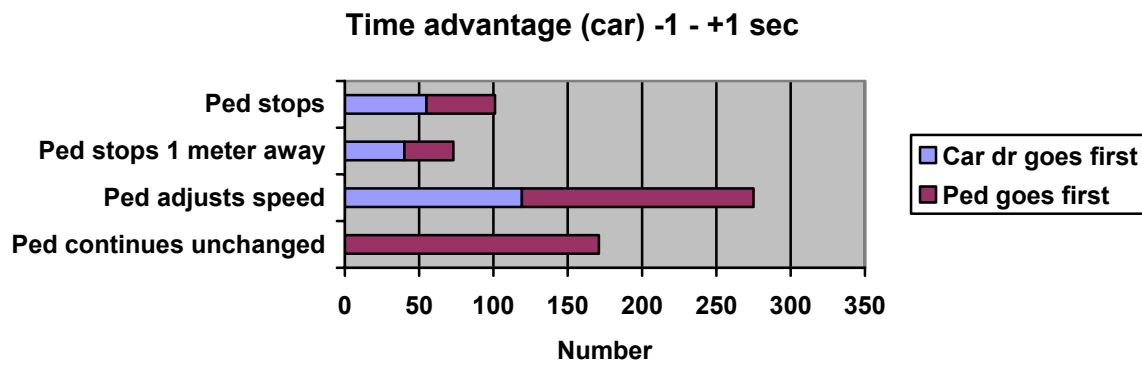


**FIGURE 10 Time advantage (car) ≤ -1 sec, pedestrian interactions**

*Pedestrians stopping: 35 % (27 % of which stopped 1 meter away)*

*Pedestrians adjusting speed: 28%*

*Pedestrians continue with unchanged speed: 36 %*

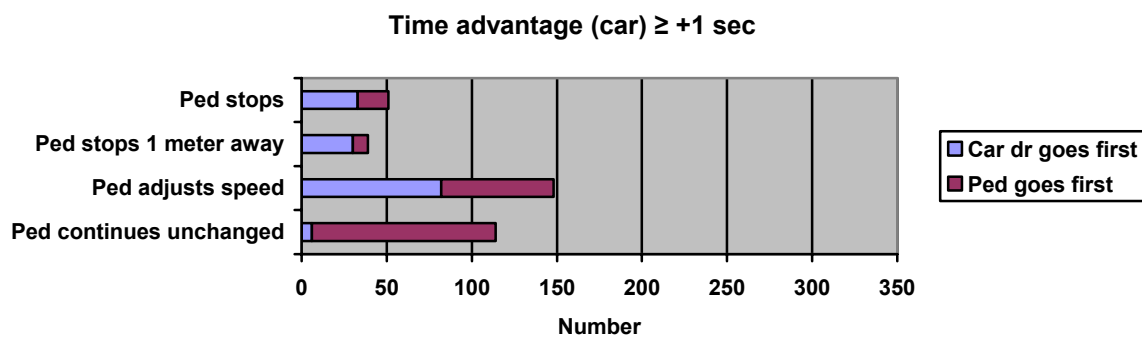


**FIGURE 11 Time advantage (car) -1 sec to +1 sec, pedestrian interactions**

*Pedestrians stopping: 28 % (42 % of which stopped 1 meter away)*

*Pedestrians adjusting speed: 44%*

*Pedestrians continue with unchanged speed: 28 %*

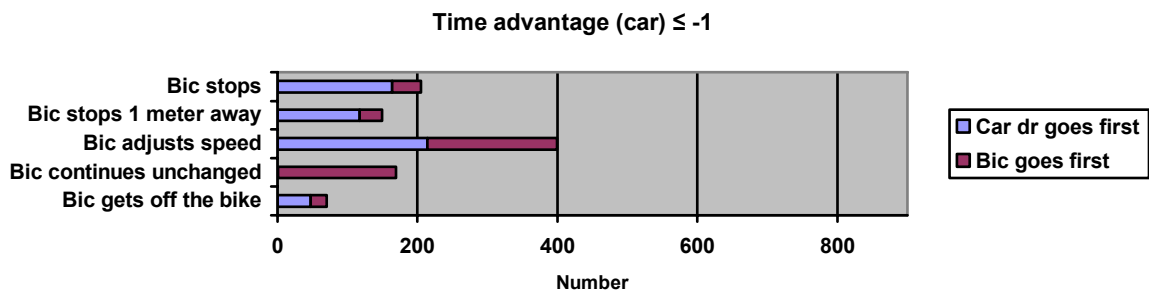


**FIGURE 12 Time advantage (car) ≥ +1 sec, pedestrian interactions**

*Pedestrians stopping: 26 % (43 % of which stopped 1 meter away)*

*Pedestrians adjusting speed: 42%*

*Pedestrians continue with unchanged speed: 32 %*

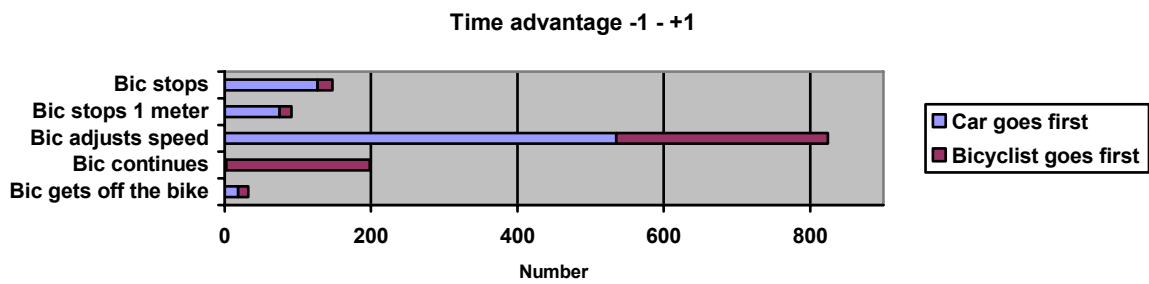


**FIGURE 13 Time advantage (car) ≤ -1 sec, bicyclist interactions**

*Bicyclist stopping: 43% (out of which 42% stopped 1 meter away and 17% got off their bikes)*

*Bicyclists adjust their speed: 40%*

*Bicyclists continue with unchanged speed: 17%*

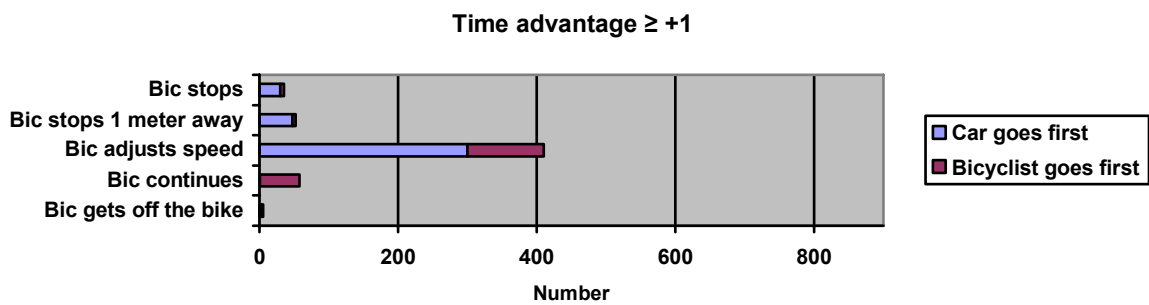


**FIGURE 14 Time advantage (car) -1 sec to +1 sec, bicyclist interactions**

*Bicyclist stopping: 21% (out of which 34% stopped 1 meter away and 12% got off their bikes)*

*Bicyclists adjust their speed: 64%*

*Bicyclists continue with unchanged speed: 15%*



**FIGURE 15 Time advantage (car) ≥ +1 sec, bicyclist interactions**

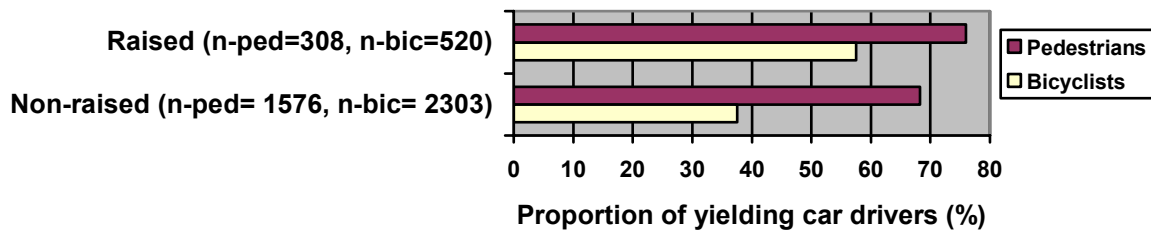
*Bicyclist stopping: 17% (out of which 57% stopped 1 meter away and 5% got off their bikes)*

*Bicyclists adjust their speed: 73%*

*Bicyclists continue with unchanged speed: 10%*

### The effect of raised crossings

Seven of the crossings were raised. The yielding behaviour by car drivers at these crossings was compared with the behaviour at non-raised crossings.



**FIGURE 16** Yielding behaviour on raised and non-raised crossings

Average speeds at raised crossings was 25 km/h and at non-raised crossings 34 km/h. Car drivers yield more often to both pedestrians and bicyclists at raised crossings (chi-square  $p \leq 0,01$  and  $p \leq 0,001$  respectively). There is good reason to believe that the lower speeds at raised crossings is the major reason why car drivers yield more often. Again, bicyclists seem to benefit quite a lot from the lower speed, while the pedestrian rate is considerably higher at both raised and non-raised crossings.

### The importance of the location of the yield signing and marking

At two of the round-about entrances studied the yield sign and yield line was located before the bicycle crossing, while at two other the yield line and signing was after the bicycle crossing, see figure 17



**FIGURE 17** Roundabouts with different location of the yielding sign and line, Sallerupsvägen/Scheelegatan and Köpenhamnsvägen/Erikslustvägen, Malmö City

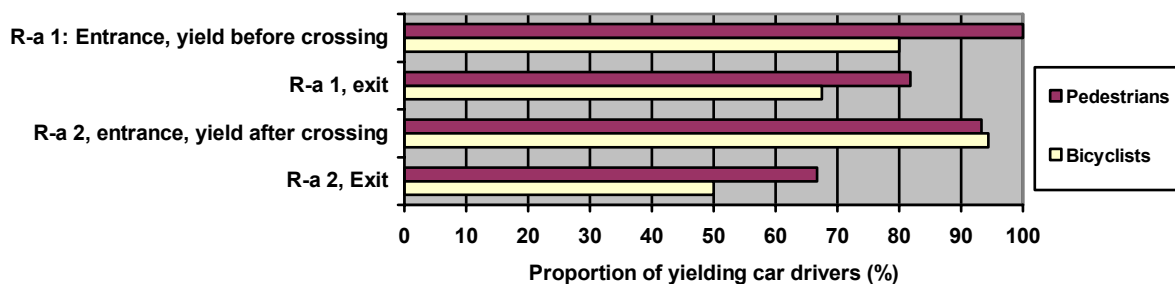
The comparison showed that there was no difference in yielding behaviour towards pedestrians, it was a bit more than 80% in both cases. The yielding towards bicyclists, however, goes up from 50% to 70% when the yielding sign and line is moved in front of the bicycle crossing. Even though 70% is a relatively high figure it indicates that we are still far from full compliance, and is still less than the yielding towards pedestrians. The reason for this may be that bicyclists is moving much faster than pedestrians and thereby may appear much more sudden than them. This would urge a change in behaviour, both by bicyclists and car drivers in order to increase the compliance with the yielding rule. This urge for a change is



of course also relevant with regard to pedestrian interactions as there is non-compliance with the yielding rule in almost 20% of the cases.

### The effect of exit entrance and exit of roundabouts on the yielding behaviour.

According to the Swedish Traffic Rules car drivers are obliged to yield for bicyclists when they (car drivers) are leaving the round-about, while this is only the case at entrances where the yield sign and line are located before the crossing: Figure 18 presents results from some different situations at roundabouts.



**FIGURE 18** Yielding behaviour at entrances and exits of roundabouts

This study is based on only two locations the results are not statistically assured. However, there is a clear tendency that car drivers yield more often for both pedestrians and bicyclists at the entrance compared with the exit. Further studies have to be done in order to verify these results. If they are “correct” they indicate an unfortunate situation because risks for pedestrians and bicyclists are normally considerably higher at exiting compared with entering an intersections. On average 75% of the accidents to pedestrians and bicyclists occur at exits (Hydén, Ståhl 1979). So a follow-up of these tentative results is highly warranted, so as also to see to it that reasons behind this possible difference is clarified, for the benefit of identifying possible remedial measures.

## SUMMARY OF RESULTS AND CONCLUSIONS

- Motorists yielded in average for 70 % of the pedestrians and 40 % of the bicyclists at pedestrian and bicycle crossings.
- Every third motorist continued with unchanged speed in interplay with a pedestrian at a pedestrian crossing even though the rules oblige them to yield.
- A yielding line positioned before the pedestrian and bicycle crossing has no impact on motorists yielding behaviour towards pedestrians but large impact on the yielding behaviour towards bicyclists (the proportion that yielded towards bicyclists increased from 50 % to almost 70 %).
- The speed of the motor vehicle traffic has great impact on the yielding behaviour, higher speeds make fewer yield, both towards pedestrians and bicyclists. The impact on the

yielding behaviour towards bicyclists is bigger than towards pedestrians. The proportion of motorists that yield towards bicyclists is tripled on crossings where the average speed is below 30 km/h compared to where it is 40-50 km/h.

- No clear relation was found between the volume of road users of different kind and the yielding behaviour.
- The proportion of motorists that yield towards pedestrians at three-armed intersections is lower than at other types of intersections. A hypothesis is that motorists generally obey traffic rules less when they go straight ahead in three-armed crossings.
- The road markings at bicycle crossings has no legal implication in any of the Nordic countries. They seem to be used in more or less the same way. The opinion of the interviewed planners is that the road markings are there partly to guide the cyclists the right way over the road and partly to make the motorists aware of crossing bicycle traffic. Many of the interviewees believe that the markings should be combined with a yielding sign, stop sign or speed-reducing measure for motor vehicles. Some of them also think that measures have to be introduced to ensure that the bicyclists slow down before the bicycle crossing.
- According to the field studies a larger amount of motorists yield towards both pedestrians and bicyclists at crossings that are levelled, however the effect is largest on the yielding behaviour towards bicyclists.
- There is a tendency that motorists yield more often towards pedestrians and bicyclists at the entry of roundabouts than at the exit. However, according to Swedish Traffic Rules, the motorists have to yield towards crossing bicyclists at the exit and not at the entry of roundabouts where the bicyclist should yield almost always (except for when there is a yield line for car before the bicycle crossing).
- Even though the interplay seems to work relatively well, it is rarely unambiguous. Rather large groups of drivers yield to both pedestrians and bicyclists and rather large groups do not yield. According to studies of the safety at pedestrian crossings, these have become even more unsafe after the traffic rules were changed on the 1<sup>st</sup> of May 2000 so that vehicle drivers are obliged to yield towards pedestrians (Thulin 2004). The situation for bicyclists is similar to that of pedestrians since between 20 % and 60 % of the drivers yield towards bicyclists at bicycle crossings (depending on, among other things, the situation and the speed of the vehicle). This variation - and the fact that far from 100 % of the drivers yield - make it probable that the safety situation for bicyclists at bicycle crossings is negatively affected in a similar way as that of pedestrians at pedestrian crossings (pedestrians feel safer at pedestrian crossings, at the same time as a large amount of the drivers do not yield).
- A consequence of this is that if the traffic rules were changed so that vehicle drivers have to yield towards bicyclists at bicycle crossings it involves a great risk that the safety situation gets even worse than today.

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