International Co-operation on Theories and Concepts in Traffic Safety

Analysis of the interactions between cyclists and right-turning motor vehicles at signalised protected intersections in Germany and the Netherlands

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Introduction

Two-thirds of all bicycle crashes with personal injuries in urban areas registered by the police happen at intersections. These critical infrastructures for safe and comfortable cycling are particularly demanding in design and operation. Therefore, there is currently a social demand in Germany for designing and operating cycle-friendly intersections, which is the subject of intense scientific debate.

One design option for safe and convenient intersections is the so-called protected intersection (PI). These originated in the Netherlands and Denmark and have been used internationally for some years, particularly in North America. These intersections are characterised by corner islands, cycle path setbacks, pedestrian islands, and bend-outs as waiting zones for motorists.

This research project aims to make a comparative analysis of the influence of the design features of protected and conventional intersections on the interactions of cyclists, pedestrians, and motorised vehicles. One of the most common conflicts is the interaction between right-turning motor vehicles and cyclists. The analysis of these interactions is presented in the following.

Data

Video observations were carried out over 95 h (4 days) on 28 approaches at 7 intersections (8 approaches with PI-features in the Netherlands | 12 approaches with PI-features in Germany | 8 approaches with features of conventional intersections in the Netherlands). Based on the video observations, the post-encroachment time (PET) was detected for all right-turning motor vehicles that clear before entering cyclists even though these cyclists have priority (leading conflicts). The interaction of cyclists entering and motor vehicles following (following conflicts) is considered to be less critical and is therefore not analysed. All PETs $\leq$ 3 s were considered for the analysis, resulting in a total of 4,274 PETs of leading conflicts.

In addition, a manual analysis of the yield of right-turning motor vehicles toward cyclists was carried out for 3 hours per approach. A distinction was made between the following levels of interactions: 1: All users behave in compliance with the rules and react in a controlled manner | 2: A cyclist can pass before the right-turning vehicle but must adapt their behaviour to avoid a collision (f.e. when the motorised vehicle brakes late or stands on the crossing) | 3: the right-turning vehicle does not comply with the rules and passes the crossing before the cyclist. This analysis is based on a total of 2,063 situations.

Infrastructure characteristics such as the bend-out, curb radius, or the lateral shift of the cycling facility are considered.

Methods

The PETs were analysed in two steps. In the first step, the distribution of the cumulative frequencies of the PET values is descriptively analysed according to the different infrastructure characteristics and the traffic volumes of all traffic types. The PET values are examined in a second step based on regression models to quantify possible influences. It is generally assumed that the number of potential traffic conflicts is related to the number of vehicles arriving. The arrivals per unit of time can be described by the Poisson distribution. If it is further assumed that the traffic conflicts (PET values ≤ 3 s) are non-negative, discrete events that are rare compared to the occurrence of interactions, a mixed Poisson distribution family can be used (as in the modelling of accidents).

The analysis of the yielding behaviour is purely descriptive based on the proportion of situations differentiated according to the interaction levels.

Results

The analysis of PETs and yielding behaviour shows no systematic differences between conventional and protected approaches. However, there are differences between the German and Dutch approaches:

Conflicts (PETs ≤ 3 s) are significantly more frequent and intense (higher proportion of PETs < 1 s) at the Dutch than at the German approaches. In addition, more right-turning vehicles were recorded not complying with the rules and passing the crossing before cyclists at the Dutch approaches. Yielding violations are significantly more frequent when cyclists arrive on green than when they start the crossing at the beginning of the green time.

Concerning further infrastructure characteristics, it has been shown that yielding violations are most frequent and intense at crossings with a bend-out of 0 to 2 metres. Only a slight difference exists between approaches with a higher bend-out (> 2 to 5 metres and > 5 metres). No differences were observed concerning the other characteristics, like the curb radius or the lateral shift of the cycling facility.

Conclusions

Based on the analysis of interactions, an effect can only be recognised concerning the bend-outs of the crossings. Nevertheless, there is a tendency for conflicts and yielding situations to be less critical with bend-outs > 2 m. However, intersection design also depends on the cycling facility in the approach. Bend-outs > 2 m can be used as an element of protected intersections, particularly where the approach has cycle paths.

It should be noted that other aspects, such as crashes, perceived safety, or the requirements of pedestrians, must be considered to derive valid recommendations.

In addition, methodological aspects such as selecting the considered infrastructure characteristics must be discussed.