Critical Behavior of Young Adolescent Cyclists in Germany

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Abstract. In 2019, around 29,000 child in Germany were injured in road accidents. The cohorts with the most accident associated victims were in their 11 to 14 year old. For this reason, the target group's behavior of those who were injured was examined for different traffic situations, which can occur during transport to or from schools. The identified peculiarities could in turn serve as an orientation for the design of traffic instructions and help reduce safety risks. Different traffic situations were chosen for the analysis, thefore collected data could serve practical purposes. In total, 3,096 road users were recorded in 17 different traffic situations. Overall, every road user caused on average 0.06 traffic conflicts and committed 1.3 errors per traffic situation. The most commonly identified riding errors were missing hand signals, not looking around correctly when turning, and using the pavement on the wrong side.

Keywords: Human factors · Cycling safety · Riding errors · Driving behavior

1 Introduction

In terms of road safety, there were approximately 29,000 child injured in road accidents in Germany in 2019 [1]. The cohorts with the most accident associated victims were in their 11 to 14 year old (the age of so called "late childhood"). Half of those 11 to 14-year-old children (around 6,400) were injured in bicycle accidents. The number of cyclists who were injured in bicycle accidents significantly increase after children change from primary to secondary school. This is due to the diverse mobility behavior which occurs during the above mentioned age. Many pupils begin to take their bikes to secondary school and the adaptation time for perception skills, motor skills as well as cognitive skills play an important role.

With regard to the awareness of transport safety among 11 to 14-year-old cyclists, research in the field of traffic education is urgently required. Even though the age group of 11 to 14-year-old counts for the most victims, there are no nationwide traffic education measures for this age group. Moreover, current research lacks a general overview of this particular group's riding behavior, which are beyond mere accident rates. For this reason, this research aimed at creating a database to cover the critical riding behavior (primarily distraction, speed behavior, bike control and conscious misconduct) of the previously

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presented target group. In order to collect data for the database, riders of the studied group were filmed to cover everyday traffic situations. In addition, eye tracking utilized to capture the data needed. Based on the data collected, peculiarities in target group's riding behavior could be identified. The identified peculiarities could in turn serve as an orientation for the design of effective traffic education. Thereby, the target group's critical riding behavior as well as risks of acceptance could be reduced in the long term and the awareness for safe cycling could be raised.

2 Overview

The 11–14 years old cyclists studied are the cohorts with the highest number of casualties or injured, both among the under-15's (cf. Fig. 1) and among all age groups (based on age-specific population size) in Germany. The number of cyclists injured in accidents rises sharply after switching from primary school to secondary school (cf. Fig. 1).

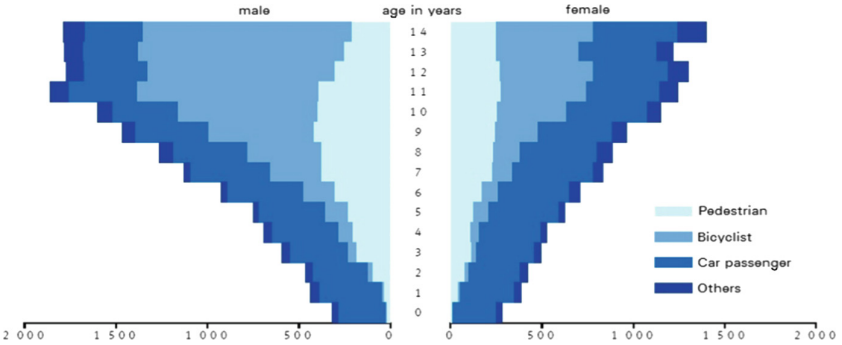

Fig. 1. Children injured in accidents during 2019 categorized by age, sex and traffic participation in Germany [1].

This increase in cyclists injuries can be attributed mainly due to a change in mobility behavior after changing schooling to secondary education compared to primary schooling, since many students start cycling to school after switching to secondary school. Perceptual, motor and cognitive abilities also play a major role. Recent studies have shown that perceptual errors for cyclists under 15 years of age are particularly frequent compared to other age groups due to age-specific physiological, motor and cognitive impairments [2, 3]. The highest proportion of cyclists involved in accidents (in relation to the population of the same age group) was in the age group of 10 to 15 year old [2]. In Finland for example, 40% of all traffic accidents involving children occur when cycling [4]. Children between the ages of 10 and 14 are twice as likely to be injured in traffic accidents when cycling with the rest of the population [5]. However, according to Keskinen [6], there are no "typical" behavior of children and adolescents in relation to those accidents, especially since there are more differences between age and gender. In a survey by Arndt et al. [7] over half of the 10 to 15-year-old students surveyed stated that they had at least one bicycle accident since they were nine years old.

Important acoustic and visual information is often not taken into account or interpreted properly by children and adolescents, at least not to the sufficient extent. Depending on the age and development of the child, the perceptional, cognitive and motor skills necessary for safe cycling are not sufficiently developed [2]. Furthermore, visual and acoustic perception in this age group is increasingly guided by interest rather than the danger of the situation. Its worth noting that at about 14 years of age the ability to concentrate over a longer periods of time can be fully developed [8].

Vansteenkiste et al. [3] developed a hazard perception test and tested it on children and adults. The results showed that children find the situation difficult to interpret correctly or to respond to important information. More knowledge about the development of situational awareness and perceptual abilities of young inexperienced cyclists could lead to more effective educational or road safety programs, and hazard recognition tests for cyclists which appear to be a valuable tool to investigate this situation. According to [8], only children aged 13–15 year old and those who are older are able to cope with the demands of road traffic when cycling. This is confirmed by the fact that in cycling accidents involving children (under 15 years of age) with personal injuries, children's misconduct leads to these accidents much more frequently than in middle or older age groups [9]. For example, Chihak et al. [10] also show that children are less able to safely cross roads by bicycle in comparison to adults.

3 Methods

Initially, both accident statistics involving 11 to 14-year-old cyclists and local accident circumstances were analyzed. Of particular importance in the analysis were thereby the causes of thise accidents, as they helped to identify peculiarities regarding accident scenes as well as accident types. Furthermore, typical riding situations for children's approach to school were analyzed. However, accidents can only illustrate the effects of hazards in road traffic. Largely overlooked were the conflict situations as well as error situations (occurring significantly more often than accidents), which do not lead to actual accidents, but are indeed caused by human misconduct. For this reason, dangerous or risky situations in road traffic, as well as safety-critical behaviors which in turn easily lead to accidents, remain undetected. A complete picture of hazard potential and accident risks in traffic can only be achieved when attention is not merely paid to the rarely occurring negative consequences of human-vehicle-environment interaction, but also to the causes and backgrounds of conflict as well as error situations.

Traffic conflicts [11, 12] and riding errors [13] illustrate situations of critical behavior and can be identified as the precursor of accidents. In contrast to actual accidents, they occur in larger numbers and can be detected reliably regardless of traffic volume. Traffic conflicts as well as riding errors illustrate hazards which can subsequently lead to accidents. In this way, critical situations, which remain un-documented in present accident statistics, but do have a strong effect on objective as well as subjective safety when cycling, can be identified. Another crucial point is the high number of bicycle accidents, especially with regard to material damage, and relatively minor personal injuries or no visible damage. Research has shown that up to 70% of all bicycle accidents in Germany were not reported or not brought to complaint [14]. Therefore, a mere consideration of

registered accidents is not sufficient. For this reason, the target group's riding behavior was examined in different traffic situations in the environment of two participating schools which can occur on the way to and from school.

Everyday traffic situations were chosen for the analysis carried in this study, therefore the collected data could be transferable to other traffic areas as well as school neighborhoods. These traffic situations were:

- Access to the road to the school with parking space, cycling and pedestrian traffic, due to the shared use as well as bringing traffic with cars ("arents' taxi"),
- Light signal-controlled crossing, due to common conflict area with pedestrians,
- Zebra crossing,
- Signaled and un-signaled T- or X-intersection (simultaneous release of right or left turn and cycling in longitudinal direction),
- Turning into motor traffic,
- Walking path, due to conflict areas with pedestrians and use of the wrong side,
- Residential area street.

The students of the two participating schools were informed about the study and the observation period, they were asked to cooperate in an orientation meeting before the initiation of the surveys. The riding behavior was recorded according to the above presented different traffic situations, and students behavior was observed via video surveillance. This contradicts the original procedure in [11] and [13], but is considered more appropriate due to the expected higher volume of bicycle traffic at the peak of the morning and the complexity of the possible situations. In this way, it is possible to differentiate between several children cycling at the same time or shortly after each other. Therefore, several video cameras were used to capture all conflicts and riding errors in the different traffic areas as well as with or without different road users. Observations took place in the mornings (one hour before the start of school) and in the afternoons (for three hours, depending on the end of day school time). Especially the traffic volume in the mornings, caused by the simultaneous start of school, provokes traffic conditions which are significantly different to those traffic conditions in the afternoons or during other times of the day. The video recordings were evaluated and compared with regard to conflicts as well as riding errors (absolute and relative).

In addition to the use of video surveillance, individual studnets were equipped with eye tracking devices on their way to and from school, which did not interfere with their behavior or response. Through eye tracking, insights into distraction factors (e.g. smartphones, side space, fellow students) could be gained. Moreover, the pupil's focus on the riding task, possible conflicts as well as error and conflict situations could be examined from their perspectives.

4 Results

In total, 3,096 road users were recorded in 17 different traffic situations. 52% of them were males and 48% of them were females. Generally, it can be stated that the target group of 11 to 14-year-old does have control over their bicycles. Only one in 100 recorded

road users did not have general control over their bicycle. However, there is a need for information regarding the subject of helmets in use. One in four students did not wear a helmet on their way to and from school (no gender-specific differences), which is interesting since various other studies found significantly lower rates of wearing a bicycle helmet (e.g. [15, 16]). Overall, every road user caused on average 0.06 traffic conflicts and committed 1.3 errors per traffic situation. There were no significant differences between boys and girls in terms of the total number of conflicts and driving errors. The most commonly identified traffic conflicts were turning into/crossing street (n = 110) and with pedestrian on the pavement (n = 40). Especially the high number of riding errors should be looked at more closely. It must be stated that in some cases several different errors can occur together (e.g. insufficiently looking around with forgotten hand signal). In general, there are only minor gender-specific differences - also with regard to the frequency of traffic conflicts as well as riding errors, which, in turn, represent the difference to the official number of adolescents injusred in traffic accidents (cf. Fig. 1). However, boys tend to forget to give a hand signal when turning right or left almost twice as often as girls do (n = 360, Odds Ratio = 1.89). Furthermore, boys fail to adapt their riding speed to environmental conditions far more often than girls do (n = 82, OR = 5.07) and frequently overtake with an insufficient safety distance (n = 214, OR = 1.45). Girls, on the contrary, tend to ride next to each other more often than boys do (n = 565, OR = 1.92) and are engrossed in conversations whilst riding (n = 329, OR = 1.75). All things considered, the most commonly identified riding errors were: using the pavement on the wrong side (counter to the direction of travel) (n = 748, error rate = 31.5%), riding next to each other (n = 565, ER = 18.3%), not getting off the bike at zebra crossings (n = 535, ER = 86.6%), insufficiently looking around when turning (n = 432, ER = 13.9%) and missing hand signals (n = 360, ER = 15.7%). Distraction also plays an essential role. As for the results of the eye tracking study (n = 42), children and adolescents in the target group were completely distracted from traffic in 7% (mean: 0.7 min) of their total driving time (mean: 10.5 min). Most often this distraction happened through eye contact with other pedestrians. During these observations with eye tracking, it was also noticed that driving together with an accompanying person leads to less safe behavior and twice as many driving errors (OR = 1.96). If the test subjects drove at the same distance alone, the number of errors can be noticeably reduced.

5 Discussion

In general, the investigation has revealed significant riding deficits among 11 to 14-year-old cyclists. Overall, on average road users caused 0.06 traffic conflicts and committed 1.3 errors per traffic situation, this looks like few conflicts. But considering how many traffic situations there are on the entire way to school, it is relatively likely that a student will cause at least one traffic conflict and make several driving errors on his or her way to school by bicycle. The majority of recorded cyclists provoked traffic conflicts and their riding errors could clearly be related to their own misconduct. Especially the negligence in turning (hand signal, looking around) which can be hazardous. Moreover, both wrong pavement use, as well as not getting off the bike at pedestrian crossings indicate a poor knowledge of existing traffic rules. An interesting finding from the accident statistics,

showed that boys are involved in accidents more often than girls, which could not be confirmed in this study, as there were no significant gender-specific differences in the amount of traffic conflicts and riding errors. The gender-specific contrast shown in the accident statistics, however, could be explained by this study which revealed facts that boys do commit more riding errors when turning, they often fail to adapt their riding speed (frequently occurring accident situations) and cycle more often in their free time than girls do. It would be appropriate to tackle those issues by developing road safety programs and instructions which consider the deficits detected in this study and refresher for the children on basic road safety education gained in primary school.

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