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Traffic conflicts and their contextual factors when riding conventional vs. electric bicycles

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ABSTRACT

The prevalence of electric bicycles (e-bikes) has increased considerably in the past few years. Because of their potential to reach higher speeds than conventional bicycles, concerns have been raised about a possible increase in traffic conflicts and crashes. The goal of this study was to examine if there are differences between conventional cyclists and e-bike riders with regard to the probability to be involved in a traffic conflict. In addition, the circumstances under which conflicts occur were investigated to identify potential differences in risk dependent on contextual factors. Utilising the naturalistic cycling approach, the personal bicycles of 80 participants (31 conventional cyclists and 49 e-bike riders) were equipped with a data acquisition system that included two cameras and a speed sensor. Four weeks of "normal" cycling were recorded for each participant. The analysis showed no difference between bicycles and e-bikes with regard to their overall involvement in traffic conflicts, as well as for the role of most contextual factors. One notable exception were intersections, where the risk of being involved in a conflict was twice as high for e-bikes as for conventional bicycles. The speed immediately preceding a conflict was higher for riders of e-bikes compared to conventional bicycles, a pattern that was also found for mean speed. While the general safety concerns regarding e-bikes could not be confirmed, the finding that e-bike riders are somewhat more at risk around intersections shows that under specific circumstances, other road users might still need time to adapt to this relatively new type of vehicle.

1. Introduction

The number of electric bicycles (pedelecs as well as S-pedelecs[2]) in the market has grown considerably in the past decade. In Europe, sales figures have increased from about 100.000 units in 2006 to nearly 1 million e-bikes in 2013 (COLIBI, 2014). The main reasons for this popularity include the reduction in cycling effort, reduced physical strain and the ability to ride for longer

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[2] In Germany, we distinguish between so called pedelecs, which support pedalling up to 25 km/h (250 W), are legally treated as conventional bicycles and constitute 95% of e-bikes sold (Zweirad-Industrie-Verband, 2015), and the faster S-pedelecs, which support up to 45 km/h (500 W), and are legally categorised as powered two wheelers, i.e. the rider needs to be in possession of a moped driving licence, and is required to wear a helmet (Lawinger & Bastian, 2013). Similar categorisations (often with consequences for licensing, insurance, etc.) exist in most European countries (Jellinek, Hildebrandt, Pfaffenbichler, & Lemmerer, 2013).

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trips (Jellinek et al., 2013). However, there are growing safety concerns. The e-bikes' potential to reach higher speeds could lead to problems for the cyclist alone (who might not be able to control the bike at high speed), and, even more critically, to conflicts in the interaction with other road users (who might underestimate the e-bike's speed; bfu-Beratungsstelle für Unfallverhütung, 2014; Skorna et al., 2010). While there is no agreement on the absolute magnitude of the difference between the speed with which conventional bicycles and e-bikes are moved in traffic (often dependent on which specific type of e-bike is observed), it is clear that there are indeed differences in operating speed (Alrutz, 2013; Jellinek et al., 2013; Langford, Chen, & Cherry, 2015; Lin, He, Tan, & He, 2007). In addition, a recent test track study found that motorists accepted shorter time gaps for crossing in front of an approaching e-bike compared to a conventional bicycle (at the same speed), just as they accepted shorter time gaps when the approaching bicycle was faster (Petzoldt, Schleinitz, Krems, & Gehlert, in press). Interview data indicate that this effect can be found also in the field, as e-bike users repeatedly reported that they were under the impression that other road users were not expecting them to approach as quickly as they did, and as a consequence, cut them off or violated their right of way (Bohle, 2015; Popovich et al., 2014). Taken together, it appears that e-bike riders might indeed be at a higher risk of being involved in traffic conflicts and crashes than users of conventional bicycles.

Unfortunately, actual crash data are hardly available. Until today, only Switzerland has gathered crash data on e-bikes for a considerable period of time in Europe (bfu-Beratungsstelle für Unfallverhütung, 2014; Weber, Scaramuzza, & Schmitt, 2014). While a clear increase in crashes with injuries involving e-bikes is reported, the authors acknowledge that the most likely explanation for this is the rapid increment of e-bike ridership. Therefore, researchers have to rely on other means to assess crash risk. A survey of cyclists seeking treatment at hospital emergency departments found that e-bike users were more likely to be involved in a crash that required treatment (Schepers, Fishman, den Hertog, Wolt, & Schwab, 2014). It might be argued that this increased likelihood to be involved in a crash requiring hospitalisation is not necessarily the result of a higher crash risk, but rather a higher crash severity when a crash does occur (i.e. a higher percentage of crashed e-bike riders end up in hospital) given e-bike riders' increased speed (Scaramuzza, Uhr, & Niemann, 2015; Schepers, Fishman, et al., 2014). Such a "reporting bias" must be expected also for actual crash statistics, once they become available (Janstrup, Hels, Kaplan, Sommer, & Lauritsen, 2014).

Field observations of road user behaviour appear to be a promising alternative to the investigation of actual crashes. So called *Naturalistic Driving Studies* (NDS), in which cars are instrumented with cameras and sensors to record "driver behaviour in a way that does not interfere with the various influences that govern those behaviours" (Boyle et al., 2012, p. 45), have been conducted for nearly two decades. As this approach does not usually yield a sufficient number of actual crashes to analyse, researchers look into safety critical events, which are used as a proxy for actual crashes (Guo, Klauer, McGill, & Dingus, 2010; Heinrich, Petersen, & Roos, 1980). These events include traffic conflicts as defined by Amundsen and Hydén (1977) as well as single vehicle incidents (e.g. run-off-road events). Due to technical limitations, only in recent years has this method become attractive also for the research of cyclist behaviour (Dozza & Werneke, 2014; Gustafsson & Archer, 2013; Johnson, Charlton, Oxley, & Newstead, 2010; Knowles, Aigner-Breuss, Strohmayer, & Orlet, 2012). Following this naturalistic approach, Dozza, Piccinini, and Werneke (2016) instrumented e-bikes with sensors and cameras to observe riders' natural cycling behaviour. The circumstances under which the risk of a conflict increases was assessed, and compared to results from a previous study that used conventional bicycles (Dozza & Werneke, 2014). The findings indicated that the situations under which the risk of a conflict increases differ between the bicycle types. However, the authors did not directly answer the question of whether certain situations are riskier for one bicycle type compared to the other.

The goal of the study presented in this paper was to investigate traffic conflicts for both conventional cyclists and e-bike riders. To accomplish that, we conducted a naturalistic cycling study that included users of both types of bicycles. The central question was whether we would find significant differences in the probability to be involved in a traffic conflict depending on bicycle type. In addition, we assessed the circumstances under which such conflicts occurred, in order to identify potential differences in risk dependent on contextual factors.

2. Method

2.1. Participants

Participants were recruited through different media, including ads in newspapers and flyers in cycling shops. Out of a larger pool of applicants, we selected those candidates for participation that used their bicycle or e-bike at least three days per week, cycled only in Chemnitz and the surrounding areas, and were the only user of the bicycle/e-bike. In addition, e-bike riders were required to have at least three months of experience riding an e-bike. In the end, a total of 80 participants (33 female, 47 male) took part in the study. Thirty-one of our participants (12 female, 19 male) owned a conventional bicycle (without motor assistance), 49 (21 female, 28 male) owned a pedelec.[3] As the e-bike user population is currently skewed towards older riders, we first recruited the e-bike riders to then match our sample of conventional cyclists in terms of age. We created three age groups: ⩽40 years; 41–64 years; and ⩾65 years. Table 1 shows the distribution of participants across age groups and bicycle types. Participants received a monetary compensation of 100€ for their collaboration.

[3] An additional group of 10 riders of S-pedelecs participated as well. However, due to its small size (and the arising consequences for data analysis), this group was not included in the analysis reported in this paper.