

What are Dangerous Car-to-Two-Wheeler Scenarios in China? A Comparison of Actual Crash Scenarios and Perceived Risky Scenarios

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I. INTRODUCTION

Two-wheelers, i.e., bicycles, motorcycles and electric powered two-wheelers, are popular means of transport worldwide, due to their low cost and easy operability, especially in congested traffic [1-2]. The fleet of motorcycles is estimated at 313 million worldwide, most of them in Asia (77%), with Europe and North America comprising only 16% of the global fleet in 2008 [3]. In China, two-wheelers constitute a considerable portion of road users [1-2] and account for 35% of road traffic deaths in 2013 [4]. During the period between 2004 and 2010, the number of total traffic fatalities decreased from 107,077 to 65,225. However, fatalities of two-wheeler riders increased from 589 to 4,029 [5-6]. The real number may still be larger due to underreporting of crashes [1].

Contributing factors and influences to actual crash risk of two-wheelers have been extensively studied based on real-life traffic crash databases. Actual crash risk for two-wheelers has been shown to be related to environment characteristics including weather, road type and existence of street lights [7-9]. A majority of the cyclist road fatalities are caused by crashes with vehicles [10-11]. Vehicle impact speed is highly associated with cyclist injury risk [12].

Driver behaviour is a more important factor than vehicle and environment [13]. Driver behaviour is largely related to the risk the drivers perceive [14-15]. Perceived crash risk is the subjective evaluation of risk by people in a specific situation. Crashes occur due to a discrepancy between perceived and actual crash risk, especially when the actual crash risk is underestimated [16]. Despite the general knowledge on drivers actual and perceived crash risk, only few studies were carried out on the perceived crash risk of drivers in China.

The aim of this study was to investigate the perceived crash risk of car drivers in encounters with two-wheelers in daily traffic. The drivers perceived crash risk was measured by means of participants ranking of risky, dangerous or annoying scenarios. The actual crash risk in this study, referred to as *actual crash scenarios* was obtained from a recently published real world crash study [17]. Further, the perceived crash scenarios of car drivers were compared with actual crash scenarios with an aim to identify the relations between them.

II. METHODS

Qualitative research in form of semi-structured individual interviews, and focus groups talks of three persons were conducted. Participants were randomly chosen from three parties: Autoliv employee family members, Geely employees and Geely customers. Included were persons holding a driving license, and being over 18 years old. Each interview took twenty to thirty minutes. All of the interviews were tape-recorded.

Design

The first part of the study consisted of structured questions about the age of the participants, gender, driving license, and driving mileage per year. Participants were then asked to recall the scenarios they have ever had with two-wheelers when they drove a car. These scenarios involved crashes, or risky and dangerous near-crash scenarios, under which the car drivers applied the brakes or steered to avoid the hazard. Scenarios which annoyed the car drivers in daily traffic were also queried, with the aim to cover more scenario in the sample and to understand the comfort of drivers when encountering two-wheelers. Information was collected including the time of the encounter (day or night), road type (intersection or straight road), rainy or not, whether the two-

wheeler was on the bicycle lane, whether there were any blind spots, intention of driving behaviour of the car driver and the two-wheeler rider, measures that car drivers took to avoid the crashes or emergency: brake or steer away. To clearly state the scenarios, the participant sketched the scenario depicting how the car and two-wheeler interacted with each other before the crash. In the end of the study, the participants were further asked to rank the scenarios they mentioned in the interview with regard to levels of danger.

Data collection and analysis

In the study, qualitative data was collected in the form of notes taken from the participants' narratives, videos about the scenario drawings and tape recordings through the whole interview. After the coding of the interview notes, conventional content analysis was applied to analyse the qualitative data [18]. Crash data was taken from a previous study of real life car-to-two-wheeler crash scenarios based on CIDAS [17]. In the paper, CIDAS data from 2011 to 2016 were analysed, yielding 830 car-to-two-wheeler crashes. In the current research, comparisons between qualitative results from interviews and crash data results from real life crashes with regard to car-to-two-wheeler scenarios and car driver behaviour were conducted.

III. INITIAL FINDINGS

Demographic Information

In total, 29 persons participated in the qualitative study, including four Autoliv employee family members, 18 Geely employees and seven Geely customers. There were 23 men and six women, aged between 28 and 60 years, with the driving license having been held between 1 - 29 years. Most participants drove less than or equal to 20,000 km per year. All of the participants' cars were fairly new, with model year within the past 10 years.

In the qualitative study, 126 scenarios were collected, around four scenarios for each participant on average. There was one scenario that the participants could not remember clearly, so it was excluded from the analysis, yielding 125 scenarios in the final results.

Relative Movement of the Car and the Two-Wheeler

By applying the same method used in the crash study [17], relative movement of the car and the two-wheeler was investigated in the qualitative study. Differences in relative movement of the car and the two-wheeler are shown in Figure 1. Perpendicular and longitudinal same direction scenarios were common both in the qualitative study and the crash study. Longitudinal opposite direction scenarios were least mentioned by car drivers in the qualitative study while in the crash study [17], a larger share of longitudinal opposite direction scenarios was observed.

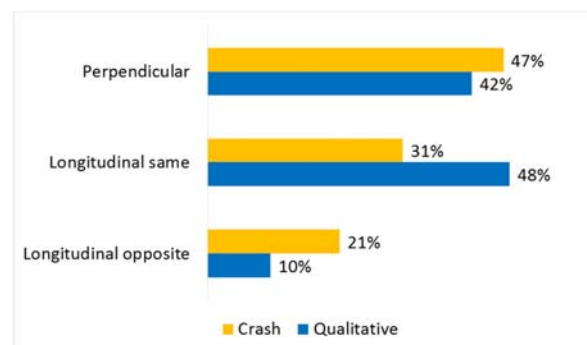


Fig. 1. Relative movement of the car and the two-wheeler.

Pre-Crash Driving behaviour of the Car and the Two-Wheeler

As shown in the Figure 2, most drivers went straightforward in both the crash study (52%) [17] and the qualitative study (56%). A similar trend was found in pre-crash driving behaviour of the two-wheeler in Figure 3.

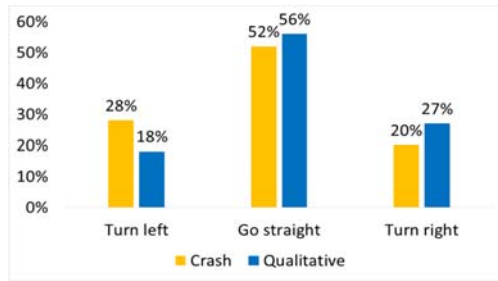


Fig. 2. Pre-crash driving behaviour of the car.

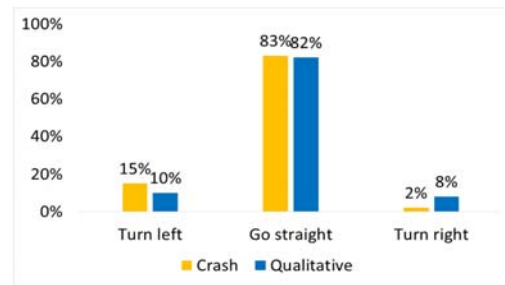


Fig. 3. Pre-crash driving behaviour of the two-wheeler.

Top Three Scenarios

By combining the relative movement between the car and the two-wheeler, pre-crash driving behaviour of the car, and the pre-crash driving behaviour of the two-wheeler, car-to-two-wheeler scenarios were identified as shown in Table I. A typical scenario only from the qualitative study is door opening on the left side after parking the car on the road.

TABLE I MEASURED PARAMETERS	
Top three actual crash scenarios [17]	Top three perceived crash scenarios

Rank of Scenarios

In the qualitative study, participants were asked to rank the scenarios they mentioned in the interviews in level of danger. When measuring the level of danger, a 5-point score was used: the most dangerous scenario got 5 points, the second 4 points, the third 3 points, the fourth 2 points, the fifth 1 point and the sixth 0 points. A higher score indicates that the scenario was more dangerous. The highest score was observed in the longitudinal same direction scenarios (Score: 164), followed by perpendicular scenarios (Score: 159) and the lowest score in the longitudinal opposite direction scenarios (Score: 33).

IV. DISCUSSION

To identify the differences between the perceived crash scenarios of drivers and actual crash scenarios, it is important to understand driver behaviour and in turn achieve better active vehicle safety design. In real world crashes perpendicular crash scenarios are most common [17], while longitudinal same direction scenarios were most commonly perceived as risky in the qualitative study. Moreover, when it comes to the rank of scenarios, longitudinal same direction scenarios were perceived as most dangerous. The perpendicular scenario, especially when both the car and the two-wheeler were going straightforward, should receive attention since it is common

in both the crash study and the qualitative study.

Longitudinal opposite direction scenarios were rarely mentioned in the interviews, and perceived as least dangerous. However, many crashes occurred in this scenario in real life traffic. It was stated that crashes often occur when there is a discrepancy between perceived crash risk and actual crash risk, especially when the perceived crash risk is underestimated [16]. From this point, an Autonomous Emergency Braking system with forward facing camera might have high potential in avoiding or mitigating such types of actual crash scenarios.

Many participants (~60%) perceived the scenario to open the door after they stopped the car risky, since there was no signal to inform the two-wheeler travelling in the same direction behind. This scenario was rarely observed in actual crash scenarios, but it brought uncomfortable driving experiences for drivers. To improve this situation, a warning system with radar assistance to detect two-wheeler driving from behind would be helpful for the car drivers.

A major limitation of this study is that the scenarios were not stratified based on different participant age groups, gender, or the places where they live. These factors are likely to affect the scenarios car drivers had with two-wheelers. Significance tests for the comparison of crash study results and qualitative results are planned for the future.

V. ACKNOWLEDGEMENTS

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