AN EXPLANATORY MECHANISM FOR RIGHT-HOOK CRASHES AT SIGNALIZED INTERSECTIONS

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ABSTRACT (APPLY STYLE ABSTRACT)

Bicycle-motor vehicle conflicts are common at intersections and one of the most common conflict is with right-turning vehicles and through bicycles. At intersections in the U.S. without space for both a separate right-turn and bicycle lane, bicyclists are often to the right of motorists as they approach an intersection. In these situations, motorists often fail to search for bicyclists, search but don’t notice approaching bicyclists, or misjudge the gap of the approaching bicyclist. In addition, bicyclists do not always position themselves to be readily seen or approach at high rates of speed. Bicycle-motor vehicle crashes involving right-turning vehicles and through-moving bicycles have been typed as “the right-hook.”

The overall goal of the research in this presentation was to quantify the safety performance of alternative traffic control strategies to mitigate right-turning vehicle-bicycle crashes at signalized intersections. The ultimate aim was to provide useful design guidance to potentially mitigate these collision types at the critical intersection configurations. The research was focused on design situations present in Oregon, U.S.A. though the work is applicable to many other jurisdictions and countries with similar configurations. The objectives of the research were:

1. To comprehensively analyze the literature and to develop an understanding of the known crash mechanisms;
2. To analyze crash records and to develop an understanding of the frequency of the crash problem at intersections and guide the design of the simulator experiment;
3. To address the identified gaps in the literature and develop a fundamentally better understanding of driver and bicyclist interactions during right-turning events at signalized intersections in a driving simulator;
4. To validate the driver performance and gap acceptance in the driving simulator with field observations; and

To accomplish these objectives the research team followed a robust research plan. First, a comprehensive review of more than 150 scientific and technical articles was performed. Then a total of 504 potential right-hook crashes were identified in the Oregon reported crash data from 2007-2011. Based on these efforts, a two-stage experiment was developed in the Oregon State University (OSU) high-fidelity driving simulator to investigate the causal factors of right-hook crashes, and to then identify and evaluate alternative design treatments that could mitigate the occurrence of right-hook crashes. Elements of driver performance and gap acceptance collected in the first-stage simulator experiment were field validated to provide additional confidence in the findings.
The OSU driving simulator and an ASL Mobile eye tracker were used to conduct Experiment 1 and 2 (Figure 1).

![OSU driving simulator and Mobile Eye XG recording unit](image)

*Figure 1: OSU driving simulator (left) Mobile Eye XG recording unit (right)*

Sixty-seven people (35 male and 32 female) participated in the simulator study. Approximately 24% (11 female and 5 male) of participants reported simulation sickness at various stages of the experiment. All responses recorded from the participants who exhibited simulator sickness were excluded from the original data set. Thus, the final data set was comprised of 51 participants; 30 male (45% of total) and 21 female (31% of total).

The driving simulator experiment investigated motorist- and environment-related causal factors of right-hook crashes, using three different motorist performance measures: 1) visual attention, 2) situational awareness (SA), and 3) crash avoidance behavior. As such, the driving simulator experiment was divided into three components to address specific sets of research questions associated with each performance measure. All performance measures were assessed during right-turn maneuvers that occurred during the latter portion of the green phase at signalized intersections.

Among 51 participants completing total of 1,071 right-turns, 23 participants could not avoid a crash with a bicyclist in 26 total right-hook crash scenarios. Relative position of a bicyclist, bicyclist speed, and the presence of an oncoming vehicle were found to have a statistically significant effect on crash occurrence. Twenty-four crashes occurred with the bicyclist approaching from behind in the motorists’ blind spot and 21 of those crashes occurred in the presence of oncoming left-turning traffic. Additionally, in 23 observed crashes, bicyclists were approaching the intersection at higher speed, i.e. at 16 mph.

The research team reviewed 144 hours of video and identified 43 conflicts where the post encroachment time measured less than 5 seconds. The identification of conflicts that exactly matched the simulator was challenged by the relatively small numbers of observations per hour of collected field data, variable bicyclist speeds, and variable volumes of oncoming left-turning vehicular traffic. However, when field observations of scenarios most similar to those in the simulator were isolated, results indicated that the distribution of the surrogate measures of safety (e.g. post-encroachment times (PET) and time-to-collision (TTC)) observed in the simulator were consistent with those observed in the field. It can be concluded that the driving simulator scenarios, for which field data could be collected, modeled authentic driving conditions and that the driver interactions with adjacent bicyclists were representative of real world driver behaviors.

Approximately one conflict occurred every three hours of video, producing 43 records from the field data that were available for direct comparison to driver performance data from the simulator (Figure 2).
This research produced a very consistent and coherent narrative about the right-hook crash. The research identified the intersection configuration with a bike lane to the right of a though motor vehicle lane as the most common profile. The research proceed to identify the traffic situations that introduced the highest probabilities for driver errors. In the subsequent experiments, a carefully selected set of treatments were evaluated under these loading scenarios. The robust analysis of these driver performance measures in the simulator was interpreted based on the positive outcome on various levels of driver performance as it relates to the safety of bicyclist.