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Driving simulator evaluation of an advance warning system for safe cyclist overtaking

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Among all crashes involving cyclists, a motorist approaching a cyclist on a shared lane from behind is particularly dangerous and likely to result in serious injuries and fatalities. Previous research has highlighted that inadequate lateral distances and high vehicle speeds are among the main contributory factors of crashes involving cars overtaking cyclists.
Since new technology innovations offer the potential to increase safety and mobility, a medium-fidelity driving simulator study was conducted at the Transportation Research Institute (IMOB) of Hasselt University, Belgium to evaluate safety effects of an advanced driver-assistance system (ADAS) on cyclist overtaking by cars. The study evaluated both the effect of the ADAS system on the lateral clearance (LC) as well as the parameters affecting the LC. The study was carried out as part of the European Horizon 2020 project i-DREAMS*.
The simulated road consisted of a two-lane rural highway, with lane width of 3.00 m and no shoulders. Three events were tested: (1) overtaking cyclist riding with a constant lateral position (close to the edge line); (2) overtaking cyclist manoeuvring from the edge of the lane to the centre of the lane; and (3) overtaking two cyclists riding in parallel position (first close to the edge line and second on the centre of the lane). The order of the events was counterbalanced to minimize order effects. The ADAS was composed by a multimodal human interface (HMI) using a multistage collision warning, informing drivers well in advance about the potential danger so that an imminent collision with the cyclist may be avoided due to attentive drivers. Three priority phases were defined: (1) normal, (2) danger, and (3) avoidable accident. The ADAS included visual and audio signals, which changed in colour and intensity for the three phases. During normal driving, the warning was composed of a visual alert icon showing the presence of the cyclist and a green arrow. In the danger phase, visual and audio (beep) signals were combined with an orange arrow. In the avoidable accident phase, a double-beep audio signal was combined with a red arrow. The optimum timing to activate the warning levels was derived from literature and a pilot, and was based on a combination of LC and time-to-danger (TTD) parameters. Forty-eight drivers drove the experimental route two times, in baseline conditions and with the ADAS. The baseline always came first to avoid that drivers were aware of the research purpose before starting the baseline drive. Biographical and driving style information and knowledge / use of ADAS systems were collected for each driver, through a pre-driving questionnaire.
Given the normality and homoscedasticity of the LC data, ANOVA and t-student tests were used. The ANOVA showed a statistically significant overall effect. The t-tests showed significant differences among the events and an effect of the ADAS. During driving in baseline conditions, LC (1.15 m) was smaller in event 2 (cyclist moving from the edge to the centre of the lane) and larger (1.76 m) in event 1 (cyclist riding close to the edge). The ADAS significantly increased LC in all events: from 1.76 to 2.19 m in event 1 (25%, $p<0.001$), 1.15 to 1.49 m in event 2 (29%, $p<0.001$), and 1.46 to 1.60 m in event 3 (10%, $p=0.096$).
A general linear model showed a positive effect on the lateral clearance of the following variables: presence of the ADAS system, familiarity with the system, male gender, driving experience as car driver, and driving experience as cyclist. A negative effect was associated with the following variables: cyclist manoeuvring from the edge of the lane to the centre of the lane, cyclists riding in parallel, driver's age, and self-reported aggressive driving. In conclusion, the drivers' characteristics affected the LC and the ADAS significantly increased LC, indicating a positive safety effect on cyclist overtaking by cars.

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