International Co-operation on Theories and Concepts in Traffic Safety

The effect of speed on driver behavior when overtaking cyclists: Results from driving-simulator and test-track data

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Background

In overtaking maneuvers, drivers risk threatening cyclists' objective and perceived safety, mainly by passing too closely or fast. Speed is particularly interesting as it may vary greatly between rural and urban environments. Furthermore, speed is already part of legislation on minimum passing distances in countries like Australia (1.0 m for roads with speed limits up to 60 km/h and 1.5 m for speed limits above) or Germany (1.5 m for urban and 2.0 m for rural roads). *Approaching* speed, i.e., the speed of the overtaking vehicle before reaching the cyclist, is inherently correlated with the speed limit on the road and may have a direct implication on the passing speed, i.e., the speed when being right next to the cyclist. Furthermore, it may affect how drivers choose their overtaking strategy: *flying* (completing the overtake without a clear decrease of speed) vs. *accelerative* (slowing down behind the cyclist, possibly letting oncoming vehicles pass, and then re-accelerating to overtake). However, little previous work has investigated the effect of approaching speed on drivers' strategy choice when overtaking cyclists and, consequently, safety margins during the maneuver.

Aim

The aim of this study was to investigate the effect of drivers' approaching speed on 1) strategy choice and 2) lateral clearance.

Method

We leveraged data from two similar experiments conducted in different test environments: 1) a driving-simulator setup (SIM, the two-degree-of-freedom moving-base driving simulator Sim-IV, provided by VTI, Sweden[1]; Figure 1 a), and 2) a driver-vehicle-in-the-loop setup (DVIL, provided by Volvo Car Corporation, Sweden[2]; Figure 1 b) in which participants drove a real car on a test track (provided by Veoneer, Sweden[3]) while seeing the same simulated world as in SIM through a virtual-reality headset. In both setups, the environment consisted of a straight road stretch where participants encountered a cyclist and possibly an oncoming vehicle.

Each participant contributed six trials to the data, resulting from randomized variations of 1) approaching speed (50 km/h and 70 km/h), and 2) time-to-collision (TTC) to the oncoming vehicle (no oncoming, 9 s, 6 s), measured when the driver reached 2 s TTC to the cyclist.

[1] The Swedish National Road and Transport Research Institute (VTI; https://www.vti.se/)
[2] Volvo Car Corporation (https://www.volvocars.com/intl/)
[3] Veoneer (https://www.veoneer.com/en/home)

We employed a Bayesian logistic mixed-effects model on the data where the oncoming vehicle was present to investigate the effect of approaching speed and TTC on strategy choice. We modeled lateral clearance with a linear regression model that used the factors approaching speed, overtaking strategy, oncoming-vehicle presence, and TTC.

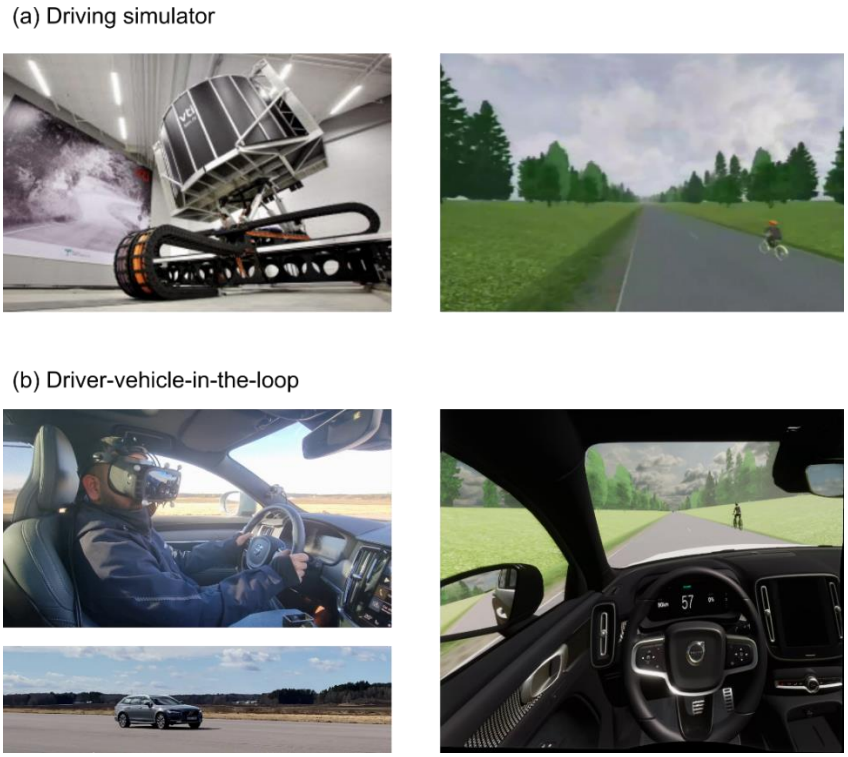

Figure 1: Data-collection environments: moving-base driving simulator Sim-IV (panel a; photo of the simulator by Hejdlösa bilder on the left, screenshot from the driver's view on the right), and driver-vehicle-in-the-loop system on a test track (panel b; driver wearing a virtual-reality headset while driving a real car on a test track on the left, driver's view on the right).

Results

The data used for statistical analyses consisted of the overtaking maneuvers performed by 25 (36% female) and 33 (18% female) participants for the SIM and DVIL setup, respectively. We found that in both environments, approaching speed had a similarly strong influence on drivers' strategy choice as TTC. In fact, at higher approaching speeds and with larger TTCs, drivers were more willing to adopt a flying strategy instead of an accelerative one. However, lateral clearance did not increase accordingly with an increase in speed, even though it decreased in the presence of an oncoming vehicle at short TTC.

Conclusions

In areas with higher speed limits, drivers may be more prone to overtake in the presence of oncoming traffic. The fact that lateral clearance did *not* increase as speed did shows that cyclists' objective and perceived safety may be more endangered, especially on rural roads with higher speed limits. This fact confirms the need to regulate minimum clearance depending on speed, as Australia and Germany do already. The similar trends found in the two test environments contribute cumulative evidence for the validity of our results.