Enhancing Novice Drivers’ Safety in SAE Level-2 Vehicles through Hazard Perception and ADAS-limitation Training

SUMMATIVE STATEMENT:
A driving simulator study found that in vehicles with Advanced Driving Assistant System (ADAS), a hazard perception training on top of a training of ADAS limitations can improve novice drivers’ takeover performance in hazardous traffic scenarios.

KEYWORDS: Driver training, ADAS, Hazard perception, Novice drivers, Takeover performance

PROBLEM STATEMENT:
In vehicles with Society of Automotive Engineers (SAE) Level-2 driving automation, drivers are still required to take over the control of the vehicle when necessary. Most previous research focused on training drivers of the ADAS limitations (e.g., DeGuzman et al., 2023). However, the timely takeover maneuver can also be related to drivers’ hazard perception skills, as the ADAS is still not good at predicting latent traffic hazards. This is especially the case for novice drivers, as they may have difficulty identifying traffic hazards and taking back control of the vehicle in time in SAE Level-2 vehicles (He et al., 2021).

OBJECTIVE/QUESTION:
Investigate whether providing drivers with ADAS limitation training or/and hazard perception training can improve novice drivers’ takeover performance in SAE level-2 vehicles or not.

METHODOLOGY:
Thirty-two participants (i.e., with a valid driver’s license for less than a year, drove less than 5000km in the past year, and without ADAS experience) were assigned to four training groups: 1) ADAS-limitation training (AD), which involved video training regarding ADAS limitations; 2) Hazard Perception training (HP), which adopted the PART training by Fisher et al. (2006); 3) Assisted Driving + Hazard Perception (AD+HP); and 4) Baseline, which provided training on basic ADAS operations. Each group included 8 drivers (4 males and 4 females). After training, they completed four drives in a fix-based driving simulator, with the order of the drives counterbalanced by Latin-square. Each drive contained one traffic hazard that required them to take over the vehicle to avoid collision. The hazards include two single-cue hazards (one behavioral prediction hazard and one environmental prediction hazard from Crundall et al. (2012)) and two multi-cue hazards (two anticipatory driving scenarios from He et al. (2021)). All hazards can be predicted by cues indicating upcoming events requiring takeover actions (i.e., hazard materialization).

Generalized linear models and mixed linear models with repeated measures were built, with hazard type (single-cue vs. multi-cue) and training (HP vs. AD vs. HP+AD vs. baseline) as independent variables. The dependent variables included 1) minimum time gap (minTG, i.e., the bumper-to-bumper distance over speed of the ego-vehicle); 2) the number of pre-actions (i.e., takeover before hazard materialization, maximum 2 for each hazard type); 3) and workload (i.e., NASA-TLX score, Hart & Staveland (1988)) reported after each drive.

RESULTS:
Training (p=.004) and hazard types (p=.003) had a significant impact on the number of pre-actions. Specifically, drivers with AD+HP training exhibited a higher number of pre-actions compared to that of baseline (p=.009) and HP alone (p<.0001). HP alone led to fewer pre-event actions.
compared to that of AD alone ($p<.0001$) and baseline ($p<.0001$). Further, more pre-actions were observed with single-cue hazards as compared to that of multi-cue hazards ($p<.0001$).

Regarding minTG, an interaction effect was observed between hazard type and training ($p=.0007$). For single-cue hazards, drivers received AD+HP training exhibited a longer minTG compared to both the HP training group ($p=.006$) and the baseline training group ($p=.001$). Moreover, drivers in the AD training group exhibited a larger minTG than those in the baseline group ($p=.045$). For multi-cue hazards, drivers receiving AD+HP training exhibited a greater minTG compared to those in the baseline training group ($p=.03$). With HP+AD ($p<.0001$) and AD training ($p=.0002$), drivers exhibited longer minTG when responding to single-hazards than to multi-hazards. Finally, training affected drivers’ perceived workload ($p=.04$) with HP+AD training led to higher workload than AD training only ($p=.04$).

DISCUSSION:

We found that the HP+AD training led to the greatest number of pre-event actions and the largest minTG in both scenarios with single-cue and multi-cue hazards, indicating that it was the most effective in improving driving safety. The AD training was also effective to some level. In scenarios with single-cue hazards, it led to longer minTG than baseline, but it did not lead to more pre-event actions. The AD training had no effects in scenarios with multi-cue hazards either. It is likely that the drivers with AD training alone may not be anticipatory enough to predict the hazards; they may also lack the capability to understand more complex scenarios with multiple cues. The higher workload with HP+AD training compared to AD training further supported the effectiveness of the HP+AD training - drivers attended to both hazards and ADAS and thus reported higher workload. Finally, it should be noted that the HP training was adopted from a non-automated driving study and not optimized for ADAS drivers. Future research with customized HP+AD training is needed.

CONCLUSIONS:

In conclusion, our study underscores the pivotal role of hazard perception training in tandem with ADAS-limitation training for enhancing novice drivers’ safety in SAE Level-2 vehicles. Future ADAS user training should focus on both hazard perception capability and ADAS limitations.

REFERENCES:


