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Impact of Regular and Narrow AV-Exclusive Lanes on Manual Driver Behavior

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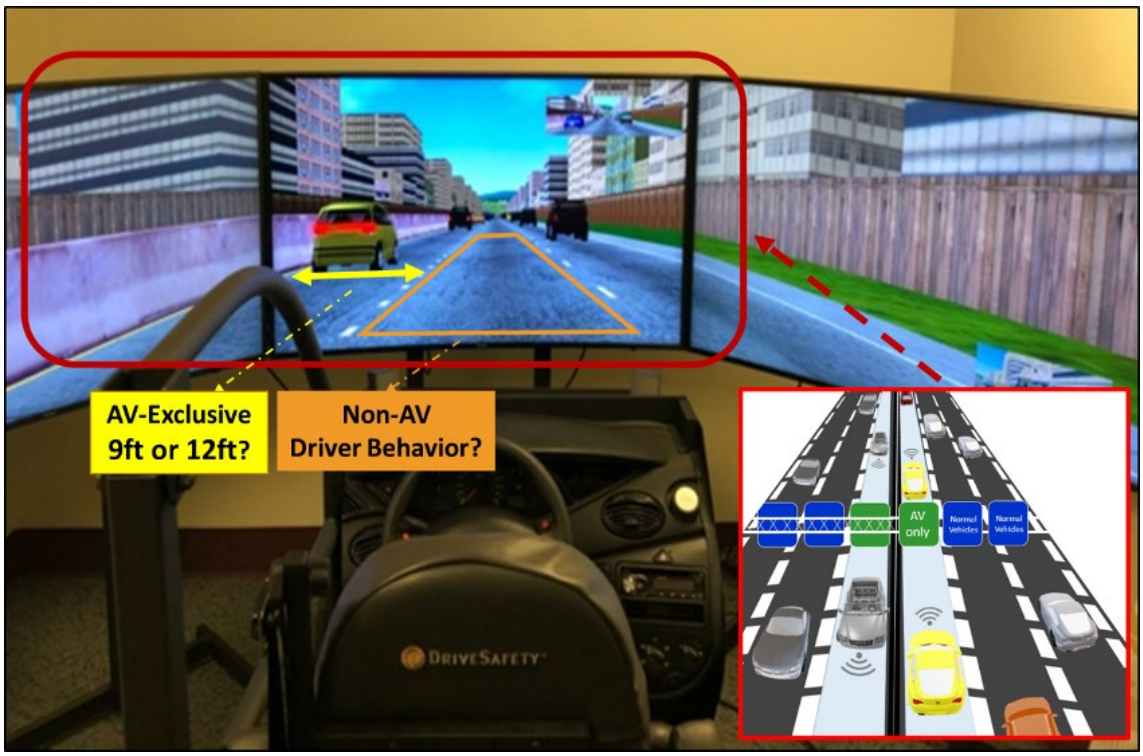

The deployment of automated vehicle (AV) technologies has profound impacts on automobile safety, mobility, operational efficiency, and the environment. As development continues, infrastructure design and standards need to be adjusted to accommodate the adaptation of AV-integrated transportation systems. However, until a complete AV market penetration happens, transportation systems will be serving both AVs and human-driven vehicles. This potentially means a mix of dedicated AV lanes and regular vehicle lanes on freeways. The primary goal of this project is to examine non-AV drivers' performance when driving adjacent to an AV-exclusive lane with a narrow width (9-ft) compared to a regular-width (12-ft) lane.

Study Methods

A driving simulator model was custom-designed to mimic an envisioned Interstate 15 (I-15)—a smart freeway in San Diego—reconfigured design including a new AV-exclusive lane. Factors in the study were width of the AV-exclusive lane (left lane), AV headways, presence of traffic on the right lane, and gender. Metrics that characterize the extent of driver behavior included mean lane positioning, mean speed, and mental effort. The driving simulator for this study was a fixed-based DriveSafety model located in the Smart Transportation Analytics Research Lab (SDSU-STAR Lab). Forty young participants were recruited, and each drove two out of the four scenarios, adjacent to either a narrow or a regular-width AV lane.

Findings

Statistical analysis did not show any statistically significant effects for mean speed or mental effort. For mean lane positioning, statistical analysis showed significant main effects for gender, presence

of right-lane traffic, and AV headway; female drivers tended to the right while male drivers tended to the left of the travel lane. Male drivers showed better lane centering behavior. Also, presence of traffic in the right lane resulted in a shift of drivers to the left side. In terms of AV headways, drivers tended to move further away from the AV lane for smaller AV headways. The results also showed some statistically significant interactions among lane width, gender, and right-lane traffic. When comparing the 9-ft group of drivers to the 12-ft group, a general shift to the left was observed when traffic was present in the right lane, and drivers showed better lane centering when driving next to the 12-ft AV lane. When looking at the group driving next to the 9-ft lane, again, a general shift to left side was observed in the presence of right-lane traffic. Female drivers drove further away from the 9-ft lane. Male drivers showed better lane centering in general and specifically when there was no traffic in the right lane. However, females had a better lane centering when there was traffic in the right lane.

When driving adjacent to a narrow (compared to regular-width) AV-exclusive lane, change in lane positioning was statistically significant, unlike speed and mental effort.

Policy Recommendations

The results of this study contribute to considerations of a narrow (9-ft) AV-exclusive lane on freeways compared to a regular 12-ft AV-exclusive lane. Although the overall effect of AV lane width was not statistically significant in lane positioning behavior, there were some significant interaction effects between lane width and other factors (i.e., driver gender and presence of traffic on the next regular lane to the right). The trend observed was that drivers driving next to the 12-ft lane have better lane centering compared to the 9-ft lane, and this may be of note for safety reasons. Providing highly reflective, clearly visible, and distinct lane markings could be considered as a measure to minimize this concern. Driver characteristics—in this study, gender—proved to have a significant effect on lane positioning behavior, suggesting that driver demographics may be of importance when deciding on AV lane design. The analysis also showed that the presence of right-lane traffic is generally accompanied by drivers shifting to the left. Therefore, precautions should be taken when designing a 9-ft AV lane in the presence of more than one regular lane adjacent to the AV lane. Moreover, though not statistically significant, visualization techniques showed when driving next to the 9-ft lane, more speed variations were observable, which might have safety implications. Design considerations such as physical barriers and advanced lane markings separating AVs from regular lanes could be considered in order to mitigate the potential negative effect of speed variations and regular traffic shifting to the left.

About the Authors

Drs. Ghanipoor Machiani and Jahangiri, the project PI and co-PI, are Assistant Professors in the San Diego State University (SDSU) Department of Civil, Construction, and Environmental Engineering, and Co-Directors of SDSU Smart Transportation Analytics Research (STAR) Lab. Aryan Sohrabi is a graduate research assistant at SDSU studying Computational Science with an emphasis in Data Science.

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