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Insights for the Future of Car Rental and Ridesharing: Driving Behavior Across Different Levels of Automation

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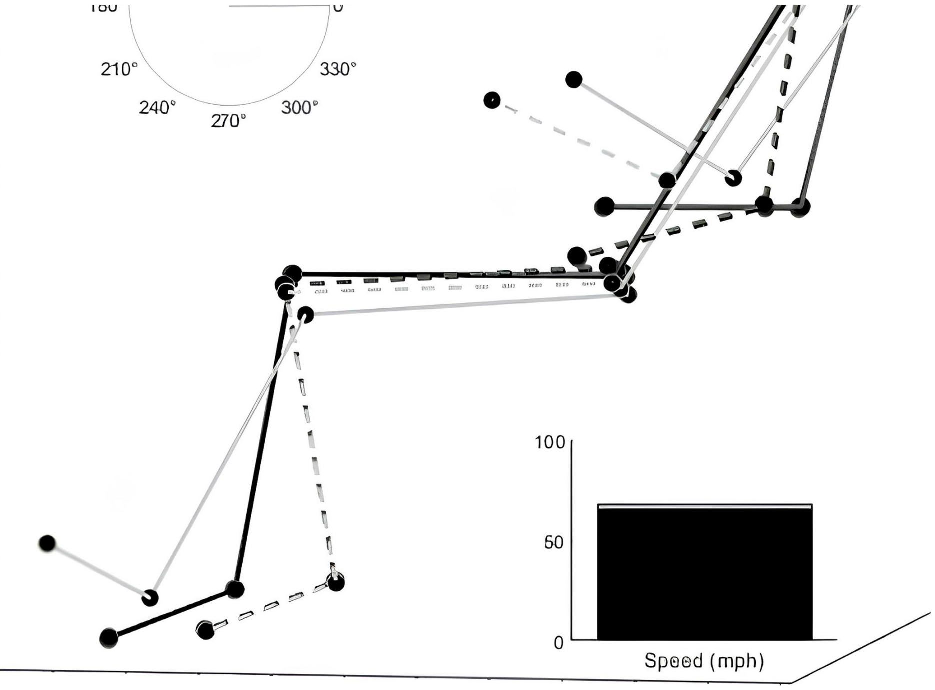

Introduction

Autonomous vehicles, such as those from Waymo, are reshaping car rental and ridesharing industries, suggesting a potential shift towards a unified model of on-demand transportation. This shift in mobility brings new challenges, and understanding human behavior in response to different levels of vehicle automation and assistance features is crucial to safety. This study explores behavior, specifically in driving performance, driving posture, and eye movement, among drivers when they drive in vehicles at different automation levels (Levels 0, 3, and 5). The study also looks at how these behaviors vary with different assistance feature styles (risky and conservative modes) and in different driving activities (lane keeping and lane changing tasks).

Study Methods

The study involved twelve participants (aged 21 to 29, 4 males and 8 females) recruited to complete six driving trials via a driving simulator (MiniSim), each lasting about 6 minutes. These trials simulated driving scenarios that required lane keeping or lane changing in response to unexpected events, under one of three levels of automation—Level 0 (manual), Level 3 (conditional automation), and Level 5 (full automation)—and one of two assistance features—conservative (early indication/action) or risky (late indication/action). During the experiment, driving performance data, including speed (in mph) and steering wheel angles (in degrees), were recorded using the driving simulator. Driving posture data, such as flexion angles of the right wrist and right ankle, as well as body positioning of various body parts were captured using a Movella/Xsens motion capture system. Eye movement data, specifically gaze coordination and pupil diameters, were tracked using a Pupil Core eye tracking system. Participants also completed pre-study, post study, and NASA-TLX questionnaires to survey their driving experience and attitudes toward automated vehicles. The collected data were analyzed and presented to identify and compare changes in driving behaviors under different automation levels and assistance features.

Findings

Transitions between manual driving (Level 0), conditional automation (Level 3), and full driving automation (Level 5) revealed short-term behavior changes as drivers interacted with vehicles at different automation levels. In Level 0, where drivers had full control, stable control of speed and steering were maintained during lane keeping and lane changing. As vehicles transitioned to Level 3, where the vehicle completed driving tasks under normal conditions with drivers' readiness still required, there was a noticeable increase in variability in speed and steering, especially under risky conditions where changes were more pronounced. At Level 5, with the vehicle fully in control, consistent speed and steering control were observed. The study also noted changes in body posture that reflected the driver's adaptation to automation levels. Eye movement also shifted with automation levels.

When drivers need to take control of a Level 3 automated vehicle, they face challenges such as adjusting to changes in vehicle behavior and getting into the right posture to

Policy Recommendations

Considering the observed changes in driving performance, body posture, and eye movement across automation levels, there are three recommendations for vehicle design and driver training that can effectively address short-term behavioral changes. First, adaptive interface and alarm systems should be implemented to capture the driver's attention across all automation levels. These systems should utilize multimodal cues—visual, auditory, and haptic—to ensure drivers can quickly and easily understand when intervention is needed, improving response time and accuracy. Secondly, the ergonomic design of vehicle controls should be enhanced to ease the physical and posture demands during transitions between different automation levels, which includes developing adjustable seating and steering mechanisms that adapt to the driver's physical state. Additionally, training programs focusing on cognitive load management should be developed to facilitate drivers' multitasking capabilities, complemented by workshops that increase driver awareness about the behavioral impacts when transitioning between different levels of automation. As autonomous vehicles become increasingly common, these considerations can help improve safety for everyone.

About the Authors

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To Learn More

For more details about the study, download the full report at transweb.sjsu.edu/research/2427

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