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Age and gender differences in emergency takeover from automated to manual driving on simulator

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ABSTRACT

Objective: The objective of this study was to explore how age and sex impact the ability to respond to an emergency when in a self-driving vehicle.

Methods: For this study, 60 drivers (male: 48%, female: 52%) of different age groups (teens: aged 16–19, 32%, adults: aged 35–54, 37%, seniors: aged 65+, 32%) were recruited to share their perspectives on self-driving technology. They were invited to ride in a driving simulator that mimicked a vehicle in autopilot mode (longitudinal and lateral control).

Results: In a scenario where the automated vehicle unexpectedly drives toward a closed highway exit, 21% of drivers did not react at all. For this event, where drivers had 6.2 s to avoid a crash, 40% of drivers crashed. Adults aged 35–54 crashed less than other age groups (33% crash rate), whereas teens crashed more (47% crash rate). Seniors had the highest crash rate (50% crash rate). Males (38% crash rate) crashed less than females (43% crash rate). All participants with a reaction time less than 4 s were able to avoid the crash.

Conclusions: The results from the simulation drives show that humans lose focus when they do not actively drive so that their response in an emergency does not allow them to reclaim control quickly enough to avoid a crash.

KEYWORDS
Self-driving; driverless; ADAS; driving simulator; emergency takeover

Introduction

Previous research has highlighted differences in behavior by gender and age in both simulator and naturalistic studies (Seacrist et al. 2016). This study used a driving simulator to explore the impact of age and sex on the ability to identify a critical driving situation and safely take over in an emergency. Driving simulators are useful for measuring driving performance, particularly in dangerous situations that cannot be replicated in an on-road environment. Driving simulators allow for safe, controlled environments where a large amount of data can be easily recorded. Furthermore, driving simulators allow researchers to present identical situations to all subjects, which is impossible with on-road studies to date. For this study, the research team recruited a cohort of 60 drivers of various ages and both sexes. This article summarizes how drivers behaved while autopilot was engaged, focusing on reaction time and crash rates, in regards to age and sex.

Methods

Data were collected at 60 Hz with a fixed-base high-fidelity Realtime Technologies, Inc. driving simulator consisting of a driver seat, 3-channel 46-in. LCD panels (180° field of view) with rearview mirror images inlaid on the panels, active pedals, steering system, and a rich audio environment. SimObserver, a video capturing system, allowed for analysis of digital video recordings of the driving scene, the participant's hands on the wheel, and the participant's feet, along with recorded simulator data.

Participants

We recruited participants from the Philadelphia, Pennsylvania area from 3 specific age groups while maintaining sex parity: Teen drivers aged 16–19 with at least 3 months of independent driving experience, adult drivers aged 35–54 with at least 5 years of independent driving, and older drivers aged 65 and with at least 5 years of independent driving experience. Participants who reported claustrophobia or nausea when riding a vehicle were not eligible for the study. Participants who owned an advanced driver assistance system (ADAS)-equipped vehicle, played more than 1 h of a driving video game per week, or had a diagnosis of ADHD were not eligible for the study. No other information on medical condition or drug use was collected. Our final cohort consisted of 19 teens (aged 16–19), 22 adults (aged 35–54), and 19 seniors (aged 65+).

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Supplemental data for this article can be accessed on the publisher's website.

Procedure

This study was approved by the Institutional Review Board of the Children's Hospital of Philadelphia. Before driving in the simulator, all 60 participants were interviewed about their driving behaviors. Participants were then introduced to the driving simulator's manual and automated driving controls with 10- to 15-min familiarization drives. The participants were taught how to engage the autopilot (through a lever) and deactivate it (through a lever, steering action, or pedal action). While in autopilot mode, the participant did not need to have a foot on a pedal or hands on the steering wheel. No special instructions were given to the participant about what they should do in automated mode (Belwadi et al. 2018).

The experiment consisted of 2 additional 15-min drives, which both presented an autopilot failure. The first experimental drive is the focus of this article. The scenario placed drivers on a highway. Drivers were asked to engage the autopilot. After about 10 min, the autopilot steered the participant's vehicle into a closed highway exit, blocked by a police car (Figure A1, see online supplement). Participants had to steer away or brake within 6.2 s to avoid a collision with the police car. At no point in the study were participants told that the autopilot would fail. Participants were then interviewed about their thoughts on self-driving vehicles, given the simulated autopilot failure they had experienced.

Data collected

A logging software component, SimObserver, was used to record driving data and videos during the experiment. An eye-tracker was worn by participants in the simulator. Simulator data consisted of numerical (csv) and video (mpg) files. All data files were saved locally by the simulator (SimObserver 2004) and were then uploaded to a secure limited access research server. Driving simulator data were analyzed with MATLAB version 17 and Python 3.

Results

Simulation results

In accordance with institutional review board requirements, participants who became somewhat dizzy or uncomfortable riding in the simulator were able to skip the simulation portion of the study. Their impressions were still collected in the postride semistructured interview. Of the 60 initial participants, 13 (5 adults and 8 seniors) had to be excluded from the study because of driving simulator sickness, leaving 47 participants who completed simulator drives. The event, which was programmed to feature a crash 6.2 s after the autopilot failure, saw a crash rate of 40%. Out of the three age groups, adults ages 35 to 54 crashed the least (33% crash rate). Teens crashed more (47% crash rate). Seniors crashed the most (50% crash rate). All participants with a reaction time less than 4 s were able to avoid the crash. Twenty-one percent of drivers did not react at all. Crash results are reported in Table A1 (see online supplement). Participants' trajectories during the event and their reactions to the event (brake vs. swerve) are reported in Figure A2 (see online supplement).

Interviews

All 60 participants completed a first semistructured interview before the drive. This interview focused on their driving behaviors and knowledge of ADAS and self-driving technology in general. A second interview after the driving simulator ride asked participants about their general impressions of the driving simulator and whether the experience had changed their views. All 60 participants were part of the postdrive interview. When asked specifically about their driving performance in the simulator, no participant suggested that simulator sickness created a bias. Of the participants who owned a vehicle with cruise control, we found that 44% of males and 25% of females used cruise control. There was less of a difference between age groups: 31% of teens, 37% of adults, and 35% of seniors used cruise control. After the driving simulator experience, participants were asked whether there was a need to educate drivers with regard to automation, and 86% of males, 94% of females, 84% of teens, 87% of adults, and 100% of seniors favored driver training for the use of automation.

A Fisher's exact test was run for categorical variables at $P < .05$ on the use of cruise control and need for education. No statistical significance could be derived using that test at $P < .05$. We noted, however, that the use of cruise control was less than 50% for all groups, which is higher than that reported in other surveys. Kamalanathsharma et al. (2015) reported that only 20% drivers never used cruise control. The discrepancy might be a result of phrasing, because we asked whether participants *preferred* using cruise control as opposed to never using it. The high level for training in ADAS (over 85% across categories) was also the focus of a study by Abraham et al. (2018). Though participants did not specifically report opinion on mandated education, they reported on expressed preference for ADAS training and the delivery method: Either at the dealership when buying a car (55%) or via the user's manual (40%).

Discussion

Until the reliability of full self-driving vehicles can be established, SAE level 2 vehicles require a human driver to monitor the driving environment and be available for fallback performance in an emergency. In the simulation, 40% of the participants crashed, suggesting that a human driver's ability to monitor the environment and respond to an emergency is lacking. As self-driving technology becomes ubiquitous, it might become necessary to envision systems that can monitor the driver's level of engagement in the driving task so that the driver can effectively take over when the autopilot feature is challenged.

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Impaired driving: A case report. Pickup truck centerline crossover collision with medium-size bus on U.S. Highway 83, Concan, Texas, United States

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ABSTRACT

Objective: The objective of this communication is to describe a crash involving an impaired pickup truck driver who crossed the centerline and struck a medium-size bus carrying senior adults restrained with lap-only belts that resulted in 13 fatalities.

Methods: Document review of the National Transportation Safety Board investigation was performed. Documents are available at: https://dms.ntsb.gov/pubdms/search/hitlist.cfm?docketID=61581&CFID=2452299&CFTOKEN=9e7f5cd49ac23dc3-47A7BE1A-B81A-1A8F-7B1554A90617B722.

Results: Prior to the crash, the erratic movement of the pickup truck being driven by a 20-year-old man was videotaped by witnesses in a following vehicle (https://www.youtube.com/watch?v=jsGsbYTwWbM). The 14.5-min cell phone recording demonstrated the pickup truck swerving repeatedly over the double yellow center line and onto the shoulder. The recording ended before the crash. While rounding a curve in the roadway, the pickup crossed the centerline and struck a medium-size bus with 14 occupants. All but one of the rearmost bus occupants were fatally injured in the collision. The pickup driver survived with serious injuries. Following the crash, toxicology testing found that the pickup truck driver had used marijuana in combination with a prescription benzodiazepine, clonazepam. The bus occupants ranged in age from 64 to 87 years old and all were wearing the available restraints, which included lap–shoulder belts and air bags (both of which deployed) for the driver and front seat passenger. Of the 12 rear passenger seats, 8 were equipped with traveling retractor lap belt assemblies and the 2-person bench seats in the last row on each side of the bus were equipped with manually adjustable lap belt assemblies.

Conclusions: The failure of the truck driver to maintain control of his vehicle was due to impairment stemming from his use of marijuana in combination with misuse of a prescribed medication, clonazepam. Following the crash, the pickup driver was sentenced to 55 years in prison. Improved countermeasures including guidance and access to improved roadside testing methods, expanded law enforcement training to detect impaired drivers, enhanced enforcement regarding impairment by combinations of drugs or drugs and alcohol, as well an evaluation and implementation of data-driven strategies are needed to reduce fatalities, injuries, and crashes involving drivers impaired by alcohol and other drugs. The lap belts provided insufficient protection for the passengers seated in the rear of the bus aft of the intrusion zone; standard installation by vehicle manufacturers of lap–shoulder belts on medium-size as well as larger buses (now required) could mitigate the risk of injury in the event of a crash.

KEYWORDS
Impaired driving enforcement; medium size bus; lap belt only bus injuries; impaired driving crashes

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