The CANdrive Program: Supporting the safer introduction of Level 2 vehicle automation

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Abstract

Vehicles on the market today now have advanced driving features that afford the driver the opportunity to take their eyes off the road and hands off the steering wheel under certain circumstances. A safety concern with these new features is the extent to which drivers may decrease the levels of attention that are directed to maintaining safety driving. We equipped a Tesla vehicle with a range of sensing technologies, including our automotive driver monitoring system, to study the impact of the advanced driving feature on the way drivers allocated their attention while driving. While drivers build trust in these newer driving features very rapidly they do change drivers' attentional strategies in ways that could impact safety. The automotive industry is acting on the need to have a thorough understanding of driver cognition by introducing driver monitoring systems in vehicles to support the safer introduction of the new wave of advanced driving features.

1 Introduction

While there is debate in scientific and industry circles about the timing of the introduction of automated vehicle functions to our roads, there is no debate that they are coming. Automated vehicle functions that allow the driver to remove him/herself from the driving task, to varying degrees, are clearly going to dramatically change the way drivers interact with vehicles. The implications of these changes on safety and related policy need to be addressed.

In the earlier stages of automated vehicle deployment, as are available on the market today, drivers will remain responsible for controlling the vehicle at all times which includes monitoring the situation to ensure they are able to manage an unexpected event if it arises. Much research shows however that people find passive monitoring tasks difficult, and struggle to pay attention. In driving, distraction is one of the primary causes of accidents. There are concerns about the impact on driver distraction linked to the introduction of vehicle automation, primarily linked to the reduced physical engagement required of the driver for much of the driving task, and potential 'overtrust' of the vehicle's ability to handle situations. Driver distraction and inattention therefore present a significant safety risk to be explored to ensure that the benefits of automated technologies can be realised.

The overarching aims of the CANdrive Program were to:

- drive improvements in vehicle technology and road safety strategy;
- drive community interest and acceptance of new vehicle technologies;
- assess the potential for automated vehicle technologies to address social mobility challenges; and
- build Canberra's reputation as Australia's technology testbed.

Seeing Machines' involvement in the program focused on two research projects that sought to examine drivers' use of and interaction with driver assistance functions that provide an introductory level of vehicle automation through control of steering and lateral control under some conditions.

2 Methodology

On a test track and public roads, we examined the impact of an advanced driver assistance system (ADAS) on driver behaviour. The ADAS provided a Level 2 driving feature allowing the driver to take their hands off the wheel and eyes off the road for defined periods. Driver attention to the forward roadway was assessed along with the impact of distraction on drivers' ability to maintain appropriate vehicle control. We also explored participants' level of trust, perceived safety and usefulness, and ease of use with regard to the available driver assistance function, given the strong link these factors are likely to have with acceptance and adoption of automated vehicles.

Two studies were conducted with a total of 60 fully-licenced ACT drivers operating a Tesla Model S vehicle equipped with a range of sensors to continuously record the drivers' behaviour and physiology as well as vehicle and road conditions. The core sensor was Seeing Machines' Driver Monitoring System (DMS) which non-invasively tracks drivers' moment-to-moment eye and head behaviour. In addition, we collected subjective measures of trust, perceived safety, usefulness, and ease of use. These measures were collected through administering questionnaires before (pre) and after (post), in addition to a semi-structured interview afterwards.

Study one measured the impact of visual distraction on drivers' ability to take back control of the vehicle in an unexpected situation. Thirty-six ACT drivers ranging in age from 23 to 75 years drove the vehicle on a test track and had the opportunity to experience the ADAS while performing a series of visually-distracting tasks, for example changing the in-car temperature or selecting music via the centre console screen. At various times and without warning, an audible alarm sounded to indicate to drivers that the vehicle was reverting to manual control and therefore the driver would have to quickly take back control. Study 2 explored more naturalistic interaction with the ADAS on public roads. Twenty-four ACT drivers ranging in age from 22 to 68 years drove the Telsa on a highway for 40 minutes. Drivers experienced the ADAS feature while engaging in a routine cognitive task often used in on-road research.

3 Key results

In study 1, measures of glance behaviour (i.e., the direction that drivers looked in, moment-to-moment) revealed drivers spent a greater proportion of time looking 'off-road' when using the ADAS feature compared to when driving manually. When visually engaged in secondary tasks drivers took significantly longer to successfully take back control of the vehicle. Following their exposure to level-2 ADAS feature on the test track, drivers expressed a high level of satisfaction with it. They also reported a greater willingness to use the technology on public roads in the future.

In study 2, positive perceptions about the ADAS feature again increased markedly even with less than one hour of experience with the system. While drivers maintained a primary focus of attention to the forward roadway both with and without the ADAS feature and the cognitive task, their scanning behaviour became more concentrated toward the road centre in a manner consistent with 'attentional tunneling' while performing the cognitive task.

Researchers observed several incidences of 'mode confusion' during data collection. Mode confusion describes a driver state where the driver has an incorrect perception of the driving mode they are in (e.g., manual or automated) for any length of time. These incidences were inferred by the researcher in real-time, and then later verbally checked with the participant to confirm or reject whether the particular incident did involve mode confusion. In the situations observed in the current study, drivers momentarily believed they were using level-2 ADAS feature but were instead driving manually. Semi-structured interviews with the drivers later indicated that many of these drivers did not recognise their misunderstanding until certain cues from the environment brought their attention to it (e.g., noticing that they were not slowing down as they approached a slower car in front of them).

4 Implications and conclusions

One of the primary safety concerns with some ADAS Level-2 driving features is that drivers may be afforded the opportunity to decrease the level of attention they direct to maintaining safe driving, and the consequent impacts on safety. In the test track environment, drivers did spend less time looking on-road when using the ADAS feature and took longer to resume manual control of the vehicle when prompted.

We found that drivers develop trust in ADAS features (i.e. Tesla's autopilot) very quickly; that is, within an hour of exposure to the system. Trust in automated vehicle technology may develop quicker than the general public expect. While this is likely to be positive in terms of user acceptance, if trust is too high it could lead to driver complacency. The risk of complacency is that drivers may fail to monitor the vehicle and the environment adequately. This is particularly problematic in the earlier stages of Level 2 ADAS deployment, where automation technology is still improving and the driver is required to be able to take over control of the vehicle at all times.

Car companies around the world are racing to implement camera-based driver monitoring systems. These systems make it possible to detect where a driver is looking and for what length of time, and can prompt the driver to increase attention to the forward roadway. For example, recognising that a driver has been looking down towards their lap (commonly associated with mobile phone use) for several seconds makes it possible to alert the driver of their unsafe behaviour.

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