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A trial of retrofitted advisory collision avoidance technology in government fleet vehicles

James P. Thompson[a,*], Jamie R.R. Mackenzie[a], Jeffrey K. Dutschke[a], Matthew R.J. Baldock[a], Simon J. Raftery[a], John Wall[b]

[a] Centre for Automotive Safety Research, The University of Adelaide, North Terrace, SA 5005, Australia
[b] Centre for Road Safety, Transport for NSW, Level 3, 84 Crown St, Wollongong, NSW 2500, Australia

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ABSTRACT

In-vehicle collision avoidance technology (CAT) has the potential to prevent crash involvement. In 2015, Transport for New South Wales undertook a trial of a Mobileye 560 CAT system that was installed in 34 government fleet vehicles for a period of seven months. The system provided headway monitoring, lane departure, forward collision and pedestrian collision warnings, using audio and visual alerts. The purpose of the trial was to determine whether the technology could change the driving behaviour of fleet vehicle drivers and improve their safety. The evaluation consisted of three components: (1) analysis of objective data to examine effects of the technology on driving behaviour, (2) analysis of video footage taken from a sample of the vehicles to examine driving circumstances that trigger headway monitoring and forward collision warnings, and (3) a survey completed by 122 of the 199 individuals who drove the trial vehicles to examine experiences with, and attitudes to, the technology. Analysis of the objective data found that the system resulted in changes in behaviour with increased headway and improved lane keeping, but that these improvements dissipated once the warning alerts were switched off. Therefore, the system is capable of altering behaviour but only when it is actively providing alerts. In-vehicle video footage revealed that over a quarter of forward collision warnings were false alarms, in which a warning event was triggered despite there being no vehicle travelling ahead. The surveyed drivers recognised that the system could improve safety but most did not wish to use it themselves as they found it to be distracting and felt that it would not prevent them from having a crash. The results demonstrate that collision avoidance technology can improve driving behaviour but drivers may need to be educated about the potential benefits for their driving in order to accept the technology.

1. Introduction

In-vehicle technologies hold great potential for improving the safety of driving. The majority of developments in technology have been directed at improving the secondary safety of vehicles, where the effects of a crash are mitigated (*e.g.* airbags). However, more recently, development of vehicle technologies has focused on improving the primary safety of vehicles, where the vehicle technology intervenes to reduce the likelihood of a crash occurring. These primary safety technologies can either enforce driver behaviours (*e.g.* alcohol interlocks), encourage safer driving behaviours (*e.g.* adaptive cruise control) or simply override the vehicle controls (e.g. electronic stability control, autonomous emergency braking).

One example of primary safety technology is collision avoidance technology (CAT), which uses a forward facing radar, lidar or camera to detect an obstacle (*e.g.* car or pedestrian) in the path of the vehicle in which it is installed. CAT systems vary, with some providing an audible or visual alert when a collision is likely, while others automatically brake the vehicle. This technology has other capabilities, such as monitoring distance and relative speed to other vehicles in the forward travel path in order to provide alerts when the following distance or approach speed is outside a predetermined distance or time threshold, referred to as headway monitoring warnings. Camera based systems can also detect lane markings or the edge of a road and monitor the position of the vehicle within the lane. Information on steering wheel angle and use of indicators can then be used to determine if the driver is unintentionally deviating from the lane and, if so, an alert is given, referred to as lane departure warnings.

Anderson et al. (2012) examined crashes in South Australia in which the configurations (*e.g.* rear-end, head-on and hit-fixed-object crashes)

* Corresponding author.
E-mail addresses: james@casr.adelaide.edu.au (J.P. Thompson), jamie@casr.adelaide.edu.au (J.R.R. Mackenzie), jeff@casr.adelaide.edu.au (J.K. Dutschke), matthew@casr.adelaide.edu.au (M.R.J. Baldock), simon@casr.adelaide.edu.au (S.J. Raftery), john.wall@transport.nsw.gov.au (J. Wall).

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suggested they would have benefitted from CAT. This research used simulation methods to estimate how collision speeds would have been modified with CAT. Changes in fatal and injury crash risk in each case were estimated using injury risk curves. Based on their simulations, Anderson et al. (2012) predicted that between 20% and 40% of all fatal crashes and between 30% and 50% of all injury crashes in light passenger vehicles (for vehicle to vehicle and vehicle to pedestrian crashes) in Australia might be prevented through CAT. These estimates were consistent with predicted reductions elsewhere of up to, and in excess of, 40% (Georgi et al., 2009; Jermakian, 2011; Kusano and Gabler, 2015; Schittenhelm, 2009). Research from the U.S. by Sayer et al. (2011) evaluated a trial of CAT that also provided drifting, lane change, and curve speed warnings. This study collected naturalistic driving data from a sample of participants who had their vehicles instrumented with the technology and found that the technology led to improvements in lane keeping, fewer lane departures, and increased turn-signal use.

In 2015, the New South Wales Government agency, Transport for NSW, undertook a trial of CAT in 34 government fleet vehicles. The technology assessed was the Mobileye system, which provides auditory and visual alerts to the driver in four situations: (1) insufficient headway to the vehicle ahead, (2) lane departure without the activation of an indicator, (3) risk of a forward collision, and (4) risk of a pedestrian collision. The system is advisory only, requiring intervention by the driver in response to the alerts. The intention of the FleetCAT trial was to determine whether this technology could improve the driving behaviour and safety of government fleet vehicle drivers and what benefits, if any, there would be in fitting the technology in a large number of vehicles. To determine whether the technology was successful, data on the frequency of events[1] provided by the system were collected and compared across three phases: Stage 1 (three months) in which the system recorded events, but gave no alerts to drivers, Stage 2 (three months) in which the system gave alerts, and Stage 3 (one month) in which the system again recorded events but gave no alerts. A reduction in warning events from Stage 1 to 2 would indicate an effect of the technology, while a reduction in warning events from Stage 1 to 3 would indicate a change in driving behaviour after exposure to the alerts.

For vehicle safety technology to be successfully implemented, there has to be a high level of acceptance[2] by the drivers who use it (Bordel et al., 2014; Regan et al., 2014). If a technology is not viewed positively, drivers will not use it and vehicle manufacturers will not wish to install it in their vehicles. For technologies (such as warning systems) that will only be effective if they prompt appropriate responses from drivers, it is crucial that users' experiences and interactions with the technology are carefully assessed. For example, users may come to ignore the alerts, or may find them more distracting than useful. As a result, the technology will not deliver the intended road safety benefits (Regan et al., 2014). Therefore, after the drivers had participated in the trial they were asked to complete a survey on their experiences of, and attitudes to, the Mobileye system. We examined the survey data to determine whether the drivers accepted the technology and whether they thought that it improved their driving.

In summary, the specific aims of the evaluation were to ascertain:

- whether the technology changed driver behaviour and improved safety,
- whether the drivers accepted the technology and thought that it improved their driving,
- whether there is evidence to support wider deployment of the technology in fleet vehicles in the long term.

2. Method

2.1. Participants

The participants were government employees who drove the fleet vehicles during the trial. Of the 199 employees who drove the 34 vehicles, 122 completed the survey (61% response rate). Multiple drivers drove each of the fleet vehicles in the trial. However, details about the number of drivers who drove each vehicle were not known. Due to workplace surveillance laws, information on the participants, the locations of vehicle use (*e.g.* urban or rural areas) and the nature of the work for which the vehicles were used was confidential, and so was not examined.

2.2. Materials

2.2.1. Collision avoidance technology

Thirty-four government fleet vehicles were retrofitted with Mobileye 560 CAT systems. This system uses a digital camera on the front windscreen and a specially designed processor to calculate dynamic distances between the vehicle and relevant objects in the traffic environment. These calculations form the basis for the provision of headway monitoring warnings (HMW), lane departure warnings (LDW), forward collision warnings (FCW), and pedestrian collision warnings (PCW). Warnings are given to the driver using visual and audio alerts on a small display unit that is installed on the vehicle's dashboard. The nature of the alerts are explained below:

- HMW – the visual alert is either a green symbol of a car and a measure of headway distance in time (seconds) or a red symbol of a car and the headway distance when the time is 0.6 s or less. The headway distance is the number of seconds it would take for the vehicle to reach the current position of the relevant road object (*e.g.* another vehicle). The audio alert tone increases in volume as the headway distance decreases. Alerts are provided when the headway distance is equal or below a pre-determined level and only when the vehicle speed is above 30 km/h.
- LDW – the visual alert is a broken white line on the side of the display that corresponds to the left or right side of the lane that the vehicle has departed. The audio alert is a loud tone. An alert is provided when the vehicle crosses over the left or right lane markings, but only when the vehicle speed is above 55 km/h.
- FCW – the visual alert is a red symbol of a car. The audio alert is a loud tone. The system alerts the driver up to 2.7 s before a collision is forecast to occur, but only when the vehicle speed is between 30 km/h and 200 km/h.
- PCW – the visual alert is a red symbol of a person. The audio alert is a loud tone. The system alerts the driver up to two seconds before a collision is forecast to occur, but only when the vehicle speed is less than 50 km/h.

All events during the trial were logged by Pinpoint TRK2003G data collection devices, which were also installed in the vehicles. The Pinpoint systems also included Global Positioning System (GPS) receivers. These receivers provided location information, from which measurements of distance travelled for each vehicle could be derived.

2.2.2. In-vehicle video cameras

Forward facing BX2000 video cameras were installed in four trial vehicles and were configured to record five seconds of footage before and after any HMW or FCW events. This footage provided greater detail about warning events that occurred in the four vehicles. This was undertaken to obtain an understanding of the typical causes and

[1] Throughout this paper, 'event' is used to refer to the Mobileye system registering an instance of insufficient headway, non-signalised lane departure or imminent forward or pedestrian collision, while 'alert' is used to refer to the audio and visual warnings that the system provides.

[2] The extent to which drivers approve of a technology after using it is called its 'acceptance', as distinct from their approval of the idea of a technology before trying it, which is called its 'acceptability' (see Adell et al., 2014).