In Two Minds: Distractive and Protective Effects of Passengers in Automated Vehicles

David R. Large[1], Cath Harvey[1], Emily Shaw[1], Sparsh Khandeparker[1], Gary Burnett[1], Elizabeth Box[2]

[1]Human Factors Research Group, University of Nottingham [2]RAC Foundation, London

SUMMARY

We highlight exemplar behaviours elicited through the observation of driver-passenger interactions in a multiple journey driving simulator study, demonstrating both distractive and protective effects when a front-seat passenger is present during SAE level 3 automated driving.

KEYWORDS

SAE level 3 automation, non-driving related task, conversation, passenger

Introduction

SAE level 3 automated vehicles (L3-AVs) (ORAD, 2021) will allow drivers to move between states of manual and automated driving. This represents a radical change in ideology, completely redefining the role of, and expectations placed upon, the driver (Shaw et al., 2020). A common proposition is that drivers will be able to engage in non-driving related tasks (NDRTs) during automation. The impact of NDRTs on driver's attention to the road scene and their ability to resume manual control remains the focus of ongoing research activities (see: Large et al, 2019 for a novel exploration). However, over one third of cars on the road contain at least one passenger (DfT, 2023). The presence of one or more passengers has been shown to distract drivers during *manual driving*, with reported reductions in situational awareness (SA), increases in the risk of taking unsafe actions and increased fatal crash risk, particularly for young drivers (Ouimet et al., 2015). Moreover, "social discomfort" caused by contentious conversations with passengers known to the driver is thought to have a negative impact on safe driving (Bremers, 2023). Nevertheless, the presence of a passenger during L3 automated driving has–to date–received no empirical attention. Aiming to address this oversight, we conducted a study similar in design to the aforementioned investigation by Large et al. (2019), but on this occasion recruited both drivers and passengers.

Method

The study took place in our driving simulator, which was modified to represent a L3-AV. Three journeys were created and framed as 'days-out' occurring over a week: visiting a shopping outlet on Monday, a walk in the country on Wednesday, and dinner with friends on Friday. Eighteen driver-passenger pairings (n=36) attended. Participants fulfilled the same role (driver or passenger) during each journey. Relationships were described as "Friends" (6 pairs), "Partners" (8) and "Work Colleagues" (4) (one from the latter cohort withdrew due to simulator sickness). Each journey began with the driver driving manually from 'their home' in a residential setting to the motorway, where automated driving was activated. An authentic motorway driving scene was created using AVSimulation SCANeR software with UK-standard signage and road markings. Social 'probes' were added to invite discussion, such as a collision/traffic jam on the counter-carriageway. Ahead of each journey, the desired destination was communicated in detail to the driver and passenger, for example: *"You're going shopping in Tyson's outlet shopping centre. You will need to exit the*

motorway at junction 33, signposted to 'A68 Tysons'. This journey should take approximately 25-30 minutes." Participants were made aware of their L3-AV's capabilities and given agency to behave as they wished during the journeys. A voice command was used to request manual control when desired, which began a 10s countdown shown on an interface in the centre console. On Day 3, an unexpected, 'emergency' 10s handover occurred, before the required junction, at approximately 11 minutes into the drive (due to "inclement weather affecting the vehicle sensors"). All participants provided ratings and qualitative comments using established questionnaires before and after each drive (trust, acceptance, SA, workload, general attitudes etc.). Journeys were videoed for analysis.

Results and Discussion

There were no significant differences in subjective ratings between drivers and passengers or, indeed, between drives. However, there were bountiful examples of novel behaviours and interactions between the driver and passenger–with both *distractive* and *protective* effects–which can inform the debate regarding performance and safety with multiple occupancy in L3-AVs.

Distractive Effects

On the first drive, 5 (out of 17) drivers requested control too late and missed their junction, ostensibly because they were distracted by the passenger. Drivers' comments highlight this concern: *"More distractions due to passenger. I would be more focused on the road without a passenger" (P0d*). Passengers also noted that their attention to the road scene waned over progressive journeys: *"Became less and less aware of the surroundings each time" (P15p).* Video analysis revealed novel behaviour, in the form of participatory NDRTs that engaged both occupants in cooperative tasks, such as watching content or playing games together on a mobile phone, jointly solving crosswords puzzles, playing cards etc. These joint tasks directed attention away from the road and delayed takeovers, particularly where there was a competitive element sustaining engagement.

Protective Effects

Conversely, many of the shared activities afforded dialogue and rather than being restrained to the activity, conversation appeared to move seamlessly between the NDRT and other topics (though none too contentious), including the driving task. For example, while watching football highlights on the passenger's mobile phone, one driver commented: *"Do you think Liverpool will win the Europa League?...Oh, there is an accident" (P5d - pointing at road)*. Moreover, comments from some drivers and passengers suggest a shared, and progressively better, engagement with the driving task: *"I could rely on the passenger to also watch the road" (P11d); "I felt more observant as the drives went on…didn't want to miss a junction" (P9p).* This behavioural adaptation and 'shared awareness' was particularly apparent during the second and third drives, with many passengers actively providing control, tactical and strategic information and advice to the driver during automation and the transfer of control (in both routine and 'emergency' situations). *All participants* subsequently took control in sufficient time to exit at the correct junction in Drive 2.

Conclusions

The study reveals both *distractive* and *protective* behaviours when a front-seat passenger is present in a L3-AV, demonstrating the importance of involving *all* potential users in the design of future vehicles. Participatory activities emerged which, while having the potential to distract drivers and reduce their attention, were also intrinsically bound with conversation, and this enabled drivers and passengers to develop a conjoined engagement with the driving situation. Results are timely given the recent announcement of the UK Automated Vehicles Bill (2023) and can inform the debate regarding permissible activities in L3-AVs and the design of in-vehicle information and functions to support and promote the safety of drivers and passengers, and, indeed, all other road users.

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