RESPONSE FROM

SEMI-AUTOMATED VEHICLE RESEARCH TEAM

RMIT UNIVERSITY

Prof. Stephen Robinson, School of Health and Biomedical Sciences, RMIT University
Prof. Mohammad Fard, School of Engineering, RMIT University
Prof. John Davy, School of Science, RMIT University
Dr. Neng Zhang, School of Engineering, RMIT University
Ms Jinhui Xu, School of Engineering, RMIT University
[redacted]

June 8, 2024

We are writing to provide feedback on the proposed Australian legislation concerning Level 3 automated vehicles. Our concerns relate primarily to the safety of the takeover response required in Level 3 automation and whether the assumed 10-second window for a driver to safely resume control of the vehicle following a takeover request is sufficient in all circumstances.

We understand that while some decisions regarding Level 3 automation have already been made, relevant legislations have not been finalised and passed into law. We trust that our feedback will inform the reframing of laws around driver responsibilities in Level 3 automated vehicles. We believe it is crucial to raise our concerns, supported by available data, to ensure the safety of all road users and pedestrians.

Our research team has considerable expertise in motor vehicle engineering, assessment of driver performance in simulated motor vehicles, and the objective measurement of cognitive and behavioural responses. Recently, our team investigated factors that influence takeover performance in Level 3 automated driving (Zhang et al., 2023a, b). This research was rigorously peer-reviewed and was published in top-tier international journals.

<u>Key findings that emerged from this research:</u>

1. Engagement in non-driving related tasks has a significant detrimental effect on driving performance during the post-automation period and affected lane control in particular.

2. As little as 5 minutes of engagement in non-driving related tasks, such as working, being entertained or resting, can increase the risk of accidents for several minutes following a takeover request.

3. Some non-driving related tasks such as being entertained or resting result in worse takeover responses than tasks that actively engage thinking (e.g. writing emails).

4. A subset of drivers displays severely degraded driving skills post-takeover, spending a considerable proportion of time (17-42%) outside of their lane for up to 5 minutes after a takeover response. This outcome highlights the individual variability in driver responses to post-automation driving tasks.

5. Drivers were unaware that their driving ability had declined after the takeover. This shows that drivers may overestimate their capacity to safely perform a takeover response.

6. Accrued driving experience significantly impacts takeover performance in conditionally automated driving, with experienced drivers exhibiting better takeover performance than inexperienced drivers. The primary determinant of a rapid and safe takeover response was a minimum of 20,000 km of driving experience. Years of driving experience was a poor predictor of takeover performance.

Since undertaking this research, we have reviewed of the published literature relevant to takeover responses in Level 3 semi-autonomous vehicles (Xu et al., 2024).

Some of the key findings to emerge from this review are:

7. The majority of studies of Level 3 autonomous driving have examined how many seconds it takes for a driver to take control of the vehicle after a takeover request. These studies have shown that drivers can successfully take control within 10 seconds. However, most of these studies failed to measure driving performance in the minutes after the takeover.

8. The relatively few studies that have examined driving performance after a takeover request have shown that at least 20-40 seconds of post-takeover driving is required before drivers recover to their normal level of driving skill.

9. Research on driver takeovers in Level 3 autonomous vehicles has focussed on population mean values. For instance, if a study of 50 subjects found that, on average, the subjects returned to normal safe driving 23 seconds after a takeover, then the value of 23 seconds will be reported. Citing mean values is standard practice in most research, and it is also standard practice to exclude outliers from consideration. However, when considering road safety, the emphasis ought to be on the outliers, as they are most likely to cause accidents. Since studies do not publish the driving performance of individual drivers, no reliable data are available concerning the extent of individual variance in takeover performance.

10. The extent of engagement in a non-driving task influences the rapidity and accuracy of a takeover. Drivers who are completely focussed on a non-driving task require far more time to return to normal levels of driving.

11. A takeover is generally more successful if the driver is given advanced warning of the need to takeover the vehicle so that they can assess the situation and prepare their response. That lead time should be a minimum of 10 seconds and the driver should have no other distractions during this period.

12. A takeover response is likely to be slower and less appropriate in complex situations (eg. urban traffic in rain at night) than in simple situations (eg. on a straight freeway in the sunshine). This is because the driver needs to spend more time assessing the situation in complex or unexpected environments before formulating a response. Responses made before the situation has been properly assessed will lead to poor decisions.

13. Most research on driving takeover responses has been conducted on young healthy university students. However, an extensive body of psychological research shows that the ability to shift attention from one task to another is influenced by age, where the length of time required to successfully switch attention increases with age and is substantially longer over the age of 50. This means that current research underestimates the time required for older drivers to successfully effect a takeover response.

14. Other factors such as fatigue, drowsiness, distraction, prescription medication use and attention deficit/hyperactivity disorder are known to be associated with slower switches of attention. However, no data are available on the extent to which these factors influence takeover responses and post-autonomous driving in Level 3 autonomous vehicles.

Recommendations

It is clear from the available data that while drivers can resume control of the vehicle within 10 seconds of a takeover request, their subsequent driving performance can be degraded for periods of between a few seconds and 5 minutes. During this period the driver can spend time dangerously out-of-lane.

The driver takeover response in Level 3 automation has been insufficiently investigated and there are major gaps in our understanding of the time required to return to normal safe driving after a takeover response, particularly in inexperienced young drivers or in older drivers. Additionally, nothing is known about how other factors, such as fatigue or common attentional disorders, affect the takeover response, and there is lack of data concerning the extent of individual variability between drivers in relation to their driving performance following takeover requests.

Primary Recommendation

In view of the currently available data, and in the absence of critically important data, we consider that driver engagement in non-driving related tasks in Level 3 semi-autonomous vehicles is risky behaviour that is certain to increase the incidence of road accidents and road fatalities. Therefore, we strongly recommend that the takeover facility in Level 3 autonomous vehicles be disabled throughout Australia, and that legislation be implemented to make it a serious offense to undertake non-driving related tasks in Level 3 autonomous vehicles.

Secondary Recommendations

If our primary recommendation is unable to be implemented, then we recommend that a raft of interventions be put in place to ameliorate the risk of road accidents and road fatalities. These interventions should include specification of design requirements for automated driving systems, regulations and laws to limit risk, and driver education. These suggested interventions are outlined below.

Design requirements for automated driving systems

i) Driver preparation can reduce switch costs, and consequently a longer lead time, free of cognitive tasks, can improve driver takeover stability. Therefore, automated driving systems should provide the driver with a minimum of 10 seconds preparation time prior to the transition to manual driving. This suggestion is in line with the United Nations Economic Commission for Europe (UNECE) specification in UN Relation No. 157 (UNECE, 2021).

ii) In order to improve the speed and accuracy of takeovers in Level 3 automation, drivers should be repeatedly exposed to takeover requests under safe conditions, until they develop automatic responses to takeover requests that are stored in their long-term memory. Such training sessions should be a programmed feature of automated driving systems.

iii) Since there is considerable variability between drivers in their speed and accuracy of takeover responses, the automated driving system should be able to build a predictive profile of the driver to anticipate the time required by the driver to return to a safe level of driving performance after a takeover. It follows from this that the automated driving system will need to be able to recognise when a different driver is behind the wheel.

iv) The automated driving system will require backup strategies that can be quickly implemented in the case of unsuccessful or error-prone takeovers.

Regulations and laws

i) Regulatory authorities will need to prescribe which types and durations of non-driving related tasks are acceptable for drivers to engage in during Level 3 conditional automated driving.

ii) The permissibility of probationary licensed drivers using Level 3 automation will require resolution before conditional automated driving is legally implemented.

iii) Authorities ought to consider what driving conditions are permissible for drivers to engage in when undertaking non-driving related tasks. Automated driving on arterial roads during the daytime in good weather may be acceptable, but do local roads at night, in rain, carry too much risk?

Driver education

i) Drivers should first acquire driving skills before using Level 3 conditional automated driving functions. It is recommended that drivers gain extensive driving experience (ideally 20,000 km of driving experience) to reduce the cognitive load associated with basic driving tasks.

ii) Drivers need to be educated about task switching and the associated decline in driving performance, particularly as drivers report no awareness that their driving performance has declined after a takeover.

iii) Drivers will need to use the manual controls regularly, as there is a risk of diminishing automaticity due to infrequency of use.

We believe it is crucial that any legislation concerning Level 3 automated vehicles prioritises the safety of all road users, including drivers, passengers, and other vulnerable road users such as pedestrians and cyclists. The responsibilities of drivers, passengers, and vehicle manufacturers must be clearly defined, with a focus on minimising the potential for human error and ensuring that the technology is implemented in a manner that enhances road safety.

Thank you for considering our feedback. We would be happy to provide additional information or clarification if needed.

References

UNECE. (2021). Concerning the Adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulations. In (Vol. UN Regulation No. 157). Geneva: United Nations Economic Commission for Europe.

Xu, J., Fard, M., Zhang, N., Davy, J. L., & Robinson, S. R. (2024). Cognitive load and task switching in drivers: implications for road safety in semi-autonomous vehicles. *Transportation Research Part F: Traffic Psychology and Behaviour (submitted).*

Zhang, N., Fard, M., Davy, J. L., Parida, S., & Robinson, S. R. (2023a). Is driving experience all that matters? Drivers' takeover performance in conditionally automated driving. *Journal of Safety Research*, *87*, 323–331. https://doi.org/10.1016/j.jsr.2023.08.003

Zhang, N., Fard, M., Xu, J., Davy, J. L., & Robinson, S. R. (2023b). Influence of non-driving related tasks on driving performance after takeover transition in conditionally automated driving. *Transportation Research Part F: Traffic Psychology and Behaviour*, *96*, 248–264. https://doi.org/10.1016/j.trf.2023.05.009