Driver Perception-Reaction Times in Level 3 Automated Vehicles

Audrey Testaferrata de Noto

Doctor of Philosophy

August 2019

Summary

In Level 3 automated vehicles the driver is allowed to engage in secondary tasks however the driver must be ready to re-engage in the driving mode if alerted to do so when such intervention is required due to the roadside circumstances. The scope of the research was to establish the Perception-Reaction Time (PRT) of drivers in a simulated Level 3 vehicle and to examine the interdependency between the person-specific characteristics in relation to different in-vehicle distractions, namely reading and writing a text message and watching a music video or film, and different type of alerts, namely a visual alert and also a combined visual and auditory alert, and subsequently compare these values with those of standard specifications used in road design in different countries for the calculation of Stopping Sight Distances (SSD).

The importance of this research is that, with the introduction of Level 3 automated vehicles, the driver needs to be alerted in a timely manner to allow for the safe handover from automated to manual vehicle control when the roadside scenarios are beyond the capacity of the vehicle automation.

The data required for the scope of this research was collected through a web-based survey which included the collection of demographic information about the respondent in the first section. The second section involved a driving simulation in a Level 3 automated vehicle with in-vehicle secondary tasks with different in-vehicle alert systems which the participant was required to react to. The PRT of the driver was taken from the moment of the alert to the moment that the participant reacted by clicking on an on-screen box.

The demographic results obtained from the survey showed that there was no significant gender difference in the perception-reaction time, the perception-reaction time increased with age and years of driving experience except for the P7 scenario except when the secondary task was reading and writing an sms and there was no significant difference in the perception-reaction time between the disabled and non-disabled groups of participants.

The PRT results obtained from the demographic data of the survey show that:

1. For the scenarios without a secondary task as a distraction and where the distraction was watching a video, the multi-sensory alert gave lower perception-reaction times;
2. For the cases where the secondary distraction was reading and writing an sms, the multi-sensory alert had a longer perception-reaction time than for the visul alert. This factor can be explained through research carried out by Wickens& Hollands (2000), Hole (2007), Cooper et al (2011) and Shinar (2007) who reported that higher demands on the cognitive resources of the participants results in causing the perception-reaction performance to degrade thus resulting in higher perception-reaction times where reading and writing an sms poses higher demand on the cognitive resources than watching a video;
3. the audio-visual alert advantage over the visual alert is effective only up to the point determined by the demand on the cognitive resources of the participant where, in this research, such point was reached for the reading and typing of a text message distraction. This is similar for the results obtained in the Ordinal Regression Model. However such multisensory alert is necessary because drivers are 11 times more likely to miss a visual alert whilst texting (Cooper et al, 2011);
4. The result of this research document gave an average perception-reaction time of 4.23 seconds based on the 85th Percentile values of the datasets taken as an average of the two worst-case scenarios where the secondary task was texting, thus reading and writing an sms.

The results further showed that the PRT obtained for the predictors collectively (Gamma Regression Model) yielded that:

1. gender is not a significant predictor when the distraction is reading and typing an sms

2. multi-sensory alert reduce gender difference in relation to PRT
3. the Age and Driving Experience predictors complement each other, with either or the other results being a significant predictor in all scenarios. Similarly, age was found to be a significant predictor in the Cluster Analysis;
4. the younger age groups have lower PRTs for all scenarios than their older counterparts both for different alerts (and same secondary task) and for same alerts (but different secondary task). Similarly, for each scenario, the Cluster Analysis revealed that the 18-30 year age group is statistically significant and formed one or more clusters in each scenario. This is also reflected in the results obtained in the Ordinal Regression Model.

When the PRT and SSD results of this research were compared with the values established for Conference Europeenne des Directeurs des Routes (CEDR), American Association of State Highways and Transportation Officials (AASHTO), National Cooperative Highway Research Programme (NCHRP), Design Manual for Roads and Bridges (DMRB), Austroads and German Design Standards (RAA), the results were as follows:

1. The PRT value resulting from this research for Level 3 Automated Vehicles is 4.23 seconds which exceeds the 2 second value adopted by CEDR, DMRB, Austroads and RAA and the 2.5 second value adopted by AASHTO and recommended by NCHRP and confirms the validity and the importance of the results of this research document. Also, the greatest difference in SSD values are most prominent for speeds of and exceeding 80km/h, which speeds are the most critical as they are the SSD values which lie beyond the visual capabilities of the driver for detecting small objects during daytime and for detecting larger objects with low contrast at night-time (Fambro et al, 1997);
2. The SSD values established by this research document exceed the values in the existing standards and guidelines with the exception of the SSD value in DMRB for a design speed of 120km/h because a lower coefficient of friction was used in this research document according to the recommendation of CEDR for a common European direction.

Permanent and temporary unexpected or new roadside scenarios necessitate that the distance ahead of alerting the driver is to be programmed according to adequate PRTs required to ensure that the driver resumes the driving task in a timely manner and avoids a collision. The results of this research document are important in this respect because such PRT values exceed the values in established and existing standard specifications as described above. Also, the introduction of Connected and Automated Vehicles (CAD) on the road creates a different concept of traffic management and how Road Traffic Control Centres will need to operate to receive, process and transmit data to and from nearby automated vehicles. Such revolutionized system will have a number of challenges, the most critical of which will be the processing of large volumes of data, cyber security and alerting vehicle drivers in advance on the approach to a critical roadside scenario.

For these reasons, the results of this research will attract the attention of researchers and road safety professionals in the years to come as the deployment of such automated vehicles continues to become a reality.