HAL open science

Impact of the driver's visual engagement and situation awareness on takeover quality

Paul Marti, Christophe Jallais, Arnaud Koustanai, Anne Guillaume, Franck Mars

► **To cite this version:**

Paul Marti, Christophe Jallais, Arnaud Koustanai, Anne Guillaume, Franck Mars. Impact of the driver's visual engagement and situation awareness on takeover quality. 7th International Conference on Driver Distraction and Inattention (DDI2021), Oct 2021, LYON, France. 5 p. hal-03388322

HAL Id: hal-03388322

https://hal.science/hal-03388322

Submitted on 29 Jul 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

7th International Conference on

Driver Distraction and Inattention

Disconnected drivers during manual, assisted, and automated driving

Online

18-20 October 2021

BOOK OF ABSTRACTS

The DDI2021 conference will take place online on 18-20 October 2021

Co-organisers:

SAFER
VEHICLE AND TRAFFIC SAFETY CENTRE AT CHALMERS

Université Gustave Eiffel

UNSW

Impact of the driver's visual engagement and situation awareness on takeover quality

Paul Marti[1], Christophe Jallais[2], Arnaud Koustanaï[3], Anne Guillaume[4], Franck Mars[5]

[1,3,4] Renault SAS, LAB, Nanterre, France
(E-mail: paul.marti@renault.com, arnaud.koustanai@renault.com, anne.guillaume@renault.com)
[2] Univ Gustave Eiffel, IFSTTAR, TS2-LESCOT, Lyon, France
(E-mail: christophe.jallais@univ-eiffel.fr)
[5] LS2N, Nantes, France
(E-mail: franck.mars@ls2n.fr)

Keywords: Automated driving; Critical events; Human factors; Non-driving task; Situation awareness

ABSTRACT

In Driving, drivers must develop and maintain a good situation awareness [3, 5]. Situation awareness (SA) involves processing the available visual information (SA level 1: perception), developing an understanding of the situation (SA level 2: comprehension) and anticipating the future states of the environment (SA level 3: projection). However, the updating of SA may be discontinuous. According to Rockwell (1988) [6] drivers tend to not spend more than two seconds without taking information about the environment. When it comes to automated driving, especially when a non-driving task is allowed, Rockwell's 2-second rule does not apply. In level 3 automated vehicles (SAE level), Zeeb et al. (2015) [7] reported that the participants looked at the central console without interruption from 2s to 55 seconds during non-driving activities, which can significantly impair and SA. In addition, many studies highlighted a deterioration of take-over quality when performing a Non-Driving Task (NDT) [1, 2, 4, 8]. In the context of the development of the level 3 automated vehicles, it is essential to understand the extent to which a loss of SA can be detrimental, especially in the event of a critical takeover request.

Objectives

The aim of the study was to evaluate the quality of takeover in a critical obstacle avoidance situation requiring good situational awareness. The relative importance of two periods preceding the takeover was focused:

- A period of 5 minutes preceding the TOR: The hypothesis was that being engaged in a secondary task during this long time prevented the construction of a mental model of the environment allowing the driver to anticipate the consequences of the obstacle's appearance (SA level 3).

- The last two seconds before the TOR: The hypothesis was that being engaged in a secondary task during this short time prevented the perception of the immediate environment just before having to deal with the critical situation (SA level 1 & 2).

Methods

96 subjects participated in this study on a fixed-base driving simulator. The driving environment was displayed on three screens. A smaller screen was dedicated to the dashboard. An 11”-tablet has been added where the center console of a real vehicle would be. It provided information on the state of vehicle automation and allowed to manually switch between manual and automated mode, or the other way around. It was also where the non-driving task was presented. The different screens were divided into several areas of interest to analyze the visual behavior of the participants.

After instructions on operation of level 3 automated vehicle and two 5-minutes training courses, the participants performed one of four automated driving conditions (see Fig. 1):

- Full_SA: the participant was not distracted and was instructed to monitor the road at all times
- SA_NDT: The participant monitored the road at all times, except during the last 2 s before the TOR when he had to read aloud a text scrolling on the tablet (non-driving task, NDT).
- NDT_SA: The participant had to perform the NDT at all time, except during the last 2 s before the TOR when he had to look at the road
- Full_NDT: The participant was distracted during the whole drive up to the TOR.

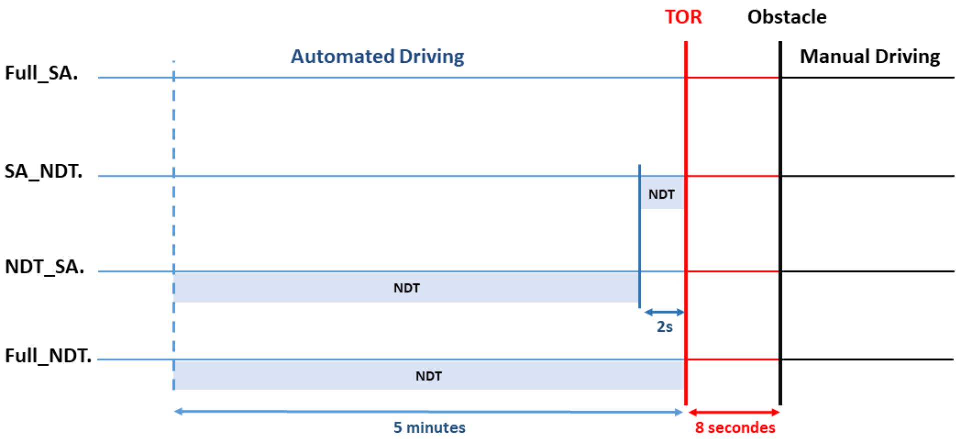

Fig 1. Automated driving conditions

The participant was driving on a 3-lane highway at 110km/h with moderate traffic. At some point, a front vehicle was placed 3 seconds ahead from the participant’s vehicle. About 38 seconds before the TOR, the participant’s vehicle began to overtake two slower vehicles. The participant’s vehicle was then in the centre lane. Right before the TOR, two faster vehicles, separated by 2 seconds, started to overtake the participant’s vehicle in order to interfere with the takeover. Then, the front vehicle started an avoidance manoeuvre because an obstacle vehicle blocked the right and centre lanes. At this moment, an auditory

2

TOR was delivered. The non-driving task was interrupted if there was one, and a red vehicle pictogram indicated the need to take over. To disable the automated mode, the driver could press a button on the tablet or use the pedals or steering wheel. To successfully intervene, the participant had to brake and fit between the two vehicles in the left lane, or to change lane after the second vehicle. Another solution consisted to stop the vehicle in the centre lane before reaching the obstacle. The time headway to the obstacle vehicle at the moment of the TOR was 8 seconds.

After completing the drive, participants were asked to report the vehicles they were aware of at the time of the TOR on a top view image of the situation. The participant’s vehicle and the obstacle were already placed at the correct scale and the participants only had to place the other vehicles.

Results

8 trials were rejected due to problems with eye-tracking data and the remaining 88 trials are evenly distributed between conditions. 45 trials resulted in a collision with another vehicle. 23 were with the first fast vehicle, 10 with the second one and 12 with the obstacle. No collisions with vehicles in the right lane occurred.

Data showed an effect of conditions on the occurrence of collisions ($Chi^2 = 8.504$, $p = < .05$). 72,73% of the participants in the Full_NDT condition had an accident, compared to 59.09% for NDT_SA and 36.36% for both Full_SA and SA_NDT. A significant effect of the conditions was found on the awareness of the first fast vehicle before the TOR ($Chi^2 = 32.267$, $p = < .05$): 81.81% of participants were aware of this vehicle for Full_SA and SA_NDT, 45.45% for NDT_SA and 9% for Full_NDT.

Another analysis was performed on the data between the time of the TOR and when the first fast vehicle disappeared in the blind spot of the participant’s vehicle (about 2.5 seconds). This period will be referred as “critical phase”. It showed a significant effect of the conditions on the number of participants looking at the left mirror and the central mirror ($Chi^2 = 13.149$, $p < 0.05$). When the total time spent on specific areas of interest was considered, there was a significant effect of the conditions on areas not related to driving ($Chi^2 = 14.83$, $p < 0.05$) (see Fig. 2.A) and on the time spent in the left and / or center mirror ($Chi^2 = 17.35$, $p < 0.05$) (see Fig. 2.B). There was no difference for the areas that displayed the driving scene ($Chi^2 = 1.17$, $p = 0.328$). Participants in the conditions Full_SA and NDT_SA spent more time looking at the left / center mirror and less time in the non-driving area compared to Full_NDT and SA_NDT.

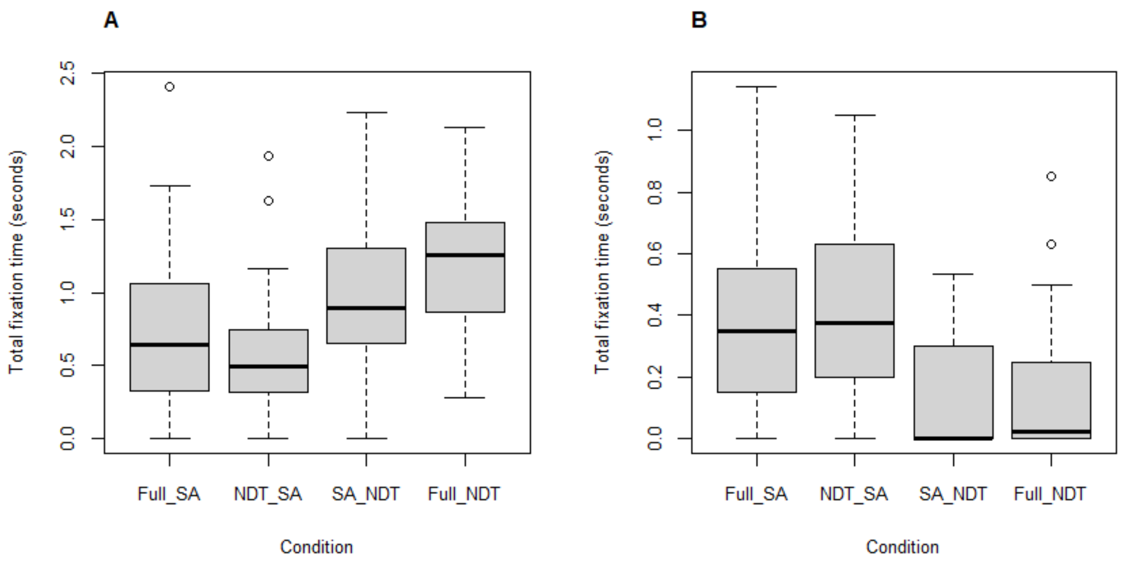

*Fig 2. Total fixation time by condition during the critical phase (**A**: on areas non-related to driving, **B**: on the central and left mirrors)*

Conclusions

The results suggest that monitoring the road at the time of the TOR facilitates adequate visual strategies in the seconds following the TOR. However, this does not appear to be decisive for the success of the takeover. If drivers have not had time to build up situational awareness before the TOR, the risk of accidents was still high even if the vision of the environment was restored 2 seconds before the TOR. Finally, it seemed more important to have good situational awareness at the time of the TOR, even if drivers had just started a non-driving task and only imperfectly checked their mirrors after the TOR. The conclusion is that, in a critical case such as the one used here, helping drivers rebuild situation awareness after the TOR does not appear to be sufficient. It may also be necessary to help the driver maintain a good situation awareness well before the TOR to ensure safety.

References

[1] Eriksson A. S. (2017) Takeover Time in Highly Automated Vehicles: Noncritical Transitions to and From Manual Control. *Human Factors: The Journal of the Human Factors and Ergonomics Society*. 59(4):689-705. doi:10.1177/0018720816685832

[2] Gold C., Damböck D., Lorenz L., Bengler K. (2013) “Take over!” How long does it take to get the driver back into the loop? *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*. 57(1):1938-1942. doi:10.1177/1541931213571433

[3] Kaber, D. B., & Endsley, M. R. (2004). The effects of level of automation and adaptive automation on human performance, situation awareness and workload in a dynamic control task. *Theoretical Issues in Ergonomics Science*, *5*(2), 113‑ 153. https://doi.org/10.1080/1463922021000054335

[4] Merat N., Jamson A. H., Lai F. C. H., Carsten O. (2012) Highly Automated Driving, Secondary Task Performance, and Driver State. *Hum Factors*. 54(5):762-771. doi:10.1177/0018720812442087

[5] Merat, N., Seppelt, B., Louw, T., Engström, J., Lee, J. D., Johansson, E., Green, C. A., Katazaki, S., Monk, C., Itoh, M., McGehee, D., Sunda, T., Unoura, K., Victor, T., Schieben, A., & Keinath, A. (2019). The “Out-of-the-Loop” concept in automated driving : Proposed definition, measures and implications. *Cognition, Technology & Work*, *21*(1), 87‑ 98. https://doi.org/10.1007/s10111-018-0525-8

[6] Rockwell, T. H. (1988). *Spare Visual Capacity in Driving-Revisited : New Empirical Results for an Old Idea*. Vision in Vehicles II. Second International Conference on Vision in VehiclesApplied Vision AssociationErgonomics SocietyAssociation of Optometrists. https://trid.trb.org/view/927089

[7] Zeeb, K., Buchner, A., & Schrauf, M. (2015). What determines the take-over time? An integrated model approach of driver take-over after automated driving. *Accident Analysis & Prevention*, *78*, 212‑ 221. https://doi.org/10.1016/j.aap.2015.02.023

[8] Zeeb K., Buchner A., Schrauf M. (2016) Is take-over time all that matters? The impact of visual-cognitive load on driver take-over quality after conditionally automated driving. *Accident Analysis & Prevention*. 92:230-239. doi:10.1016/j.aap.2016.04.002