Research
Report Summary

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Transfer from Highly Automated to Manual Control

Performance & Trust

A driving simulator study was performed with 20 participants to study transfers of control in highly automated vehicles. We observed driver performance and measured comfort as an indicator of the development of trust in the system. One scenario used an automation system that was able to respond to most events by slowing or changing lanes on its own. The other study drive issued takeover requests (TORs) in all cases. Thus there was a change in reliability over the course of the study drives, where some participants experienced the more-capable system first and others the less-capable.

Study events included a work zone, a section with missing lane lines, an elevated ramp curve, a slow lead vehicle, and an exit ramp as the final event. Extra events with lead vehicles that changed speed served as examples of successful automation interventions.

Transfer of control examples with varied expectation

	Expected	Unexpected
Lower to Higher	Button press	Collision avoidance
Higher to Lower	Grab wheel	Automation failure

A trivia task from www.triviaplaza.com was used to engage the operator while in automated mode. Rather than being a secondary task, this was the primary task during periods of automation.

Experimental Setup

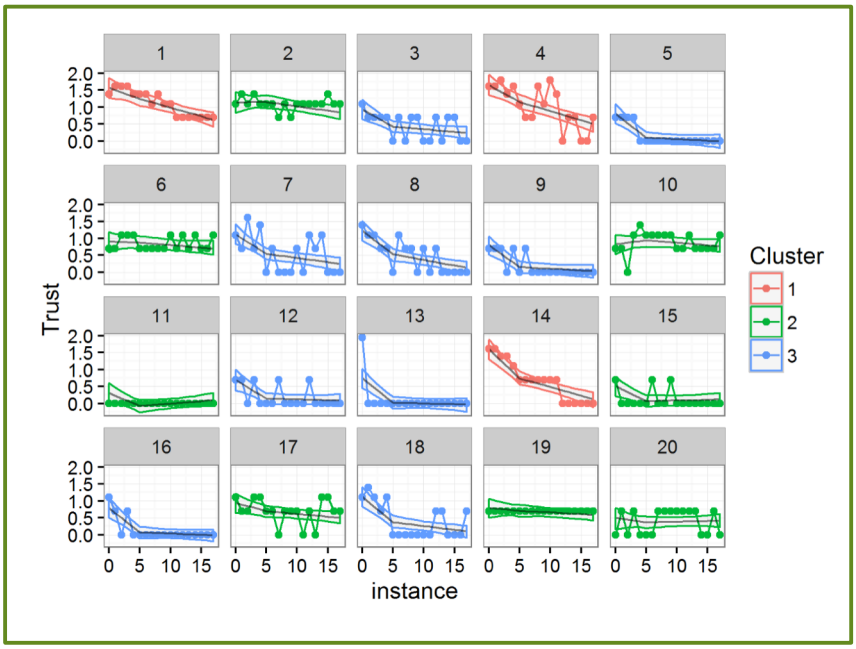
Automated-mode icon and imminent takeover request

NADS-1 motion base

Longitudinal measures

Longitudinal Measures
Comfort
Minimum speed
Mean speed
Steering reversal rate
Std. dev. lane position
High-frequency steering
Percent road center gaze

Takeover requests were modeled after the interfaces used in recent NHTSA research on level 2/3 automation (Blanco et al., 2015).



We observed three types of people with respect to their comfort profiles over the course of their three drives. Some started out very comfortable, others took a long time to become comfortable, and others increased in comfort fairly quickly.

Takeovers were split into physical takeover, visual attention, and vehicle stabilization. We did not attempt to quantify the time required to regain full situational awareness. Drivers were able to physically take control less than five seconds after being requested to. However, response time and performance measures showed that there was a 15- to 25-second period between the physical takeover and a return to normal driving performance. This confirms some observations in previous studies on transfer of control (Gold et al., 2013; Merat et al., 2014).

> *"There is a 15- to 25-second gap between physical takeover and visual attention/stabilization during which the driver may be vulnerable to missing a safety-critical event at an inopportune moment."*

No other event exposed differences between the study groups as well as the slow lead vehicle event in Drive B. Women were seen to achieve lower minimum speeds than men. Men spent more time in manual mode than did women. Younger drivers had a lower SRR and larger SDLP than did the older group. Finally, when drivers experienced this event in their first drive, they tended to have larger amounts of high-frequency steering than when they experienced it in their second drive.

References

Blanco, M., Atwood, J., Vasquez, H.M., Trimble, T.E., Fitchett, V.L., Radlbeck, J., Fitch, G.M. et al. (2015). *Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts*. Final Report DOT HS 812 182. Washington, D.C.: NHTSA.

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): 1938–42.

Merat, N., Jamson, A. H., Lai, F. C. H., Daly, M., & Carsten, O. M. J. (2014). Transition to manual: Driver behaviour when resuming control from a highly automated vehicle. *Transportation Research Part F: Traffic Psychology and Behaviour*.