



Driving simulator study on long-term effects on user acceptance and behavioural adaptation to ADF

L3Pilot Final Event



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Background – Behavioural Adaptation

- **Behavioural adaptation (BA):** *“behaviours which may occur following the introduction of changes to the road-vehicle-user system and which were not intended by the initiators of the change”* (OECD, 1990)
- Introduction of AD = change in the road-vehicle-user system
- BA to AD can occur on **different levels** (Martens & Jenssen, 2012):
 - Perceptive changes
 - Cognitive changes
 - Performance changes
 - Driver state changes
 - Attitudinal changes

Background – Changes over time

- Five phases of behavioral adaptation (Martens & Jenssen, 2012):
 - **First encounter**: depends on how intuitive the HMI is
 - **Learning**: depends on complexity of the HMI
 - **Trust**: shift of locus of control from user to vehicle
 - Adjustment
 - Readjustment
- Timely dimensions are variable

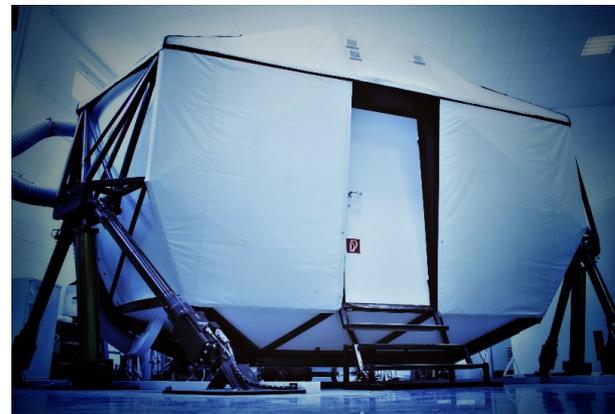
Research questions (RQ)

- L3Pilot RQs are addressed with a focus on changes over time
 - Are drivers **willing** to use an ADF?
 - What is the **user acceptance** of the ADF?
 - What is the impact of ADF on **driver state**?
 - What is the impact of ADF on **driver awareness**?
 - What is drivers' **secondary task engagement** during ADF use?
 - How do drivers respond when they are required to **retake control**?
 - How often and under which circumstances do drivers chose to **activate/deactivate** the ADF?
 - What is the **impact of driver state on user acceptance and behaviour**?

Method

Basic idea: Ordinary drivers experience several drives with an ADF in a driving simulator. Drivers are free to use the ADF as they want. Changes in user acceptance and behaviour are analyzed over time.

- N = 60 drivers
(29 females, mean age=38, SD=12)
- 6 driving sessions
- System level (L3 vs. L4) as a between factor
- Take-over requests at system limits



Data sources

- L3 Pilot questionnaire
- Eye-tracking data (SmartEye®)
- Driving data (Silab®)
- EEG data (BrainProducts) in two drives to assess sleepiness & sleep
- TOC-rating: standardized video-based controllability assessment of take-over performance
- Coding of non-driving related activities throughout the drives

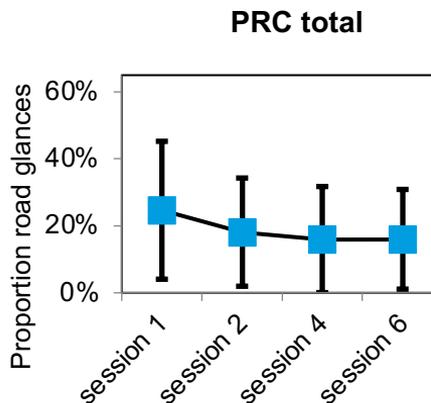
Results – Changes in perception

Indicator: Proportion of time looking at the road (PRC)
Items from L3Pilot questionnaire

Results:

With repeated usage

- Visual attention to the road decreases
- Drivers feel less the need to monitor the system



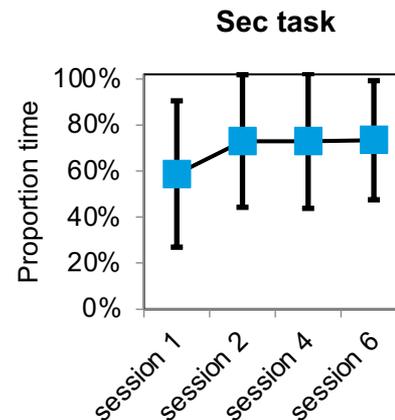
Results – Cognitive changes

Indicator: Proportion of time spent on non-driving activities
Additional questionnaire items

Results:

With repeated usage

- Drivers spend more time on non-driving related activities
- Mental model/system understanding already high after the first encounter, no changes over time



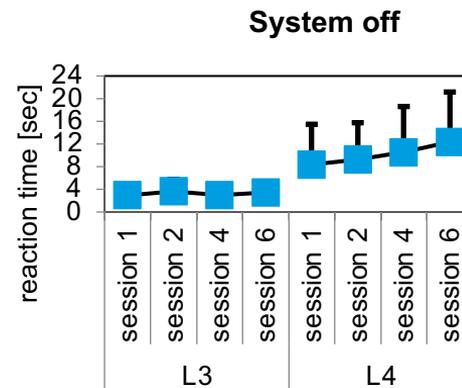
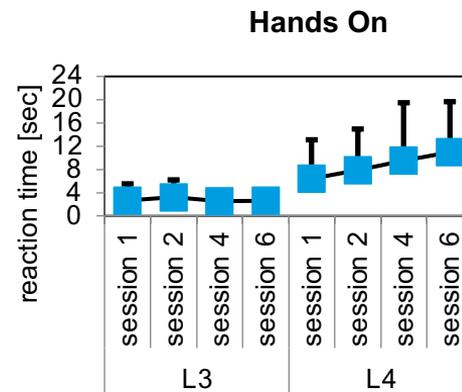
Results – Changes in performance

Indicator: Reaction time after TOR
Items from L3Pilot questionnaire

Results:

With repeated usage

- Drivers' reaction times in take-over situations increase only for the L4 ADF.
- There is no change of take-over performance
- There is no change in subjective criticality of take-over situations



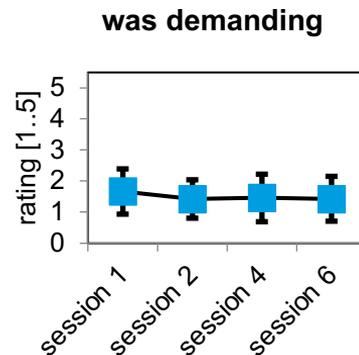
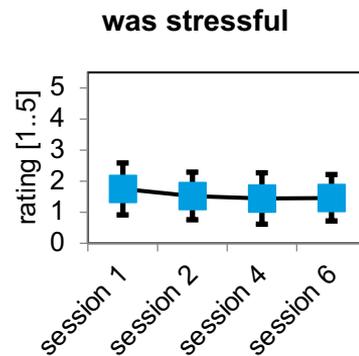
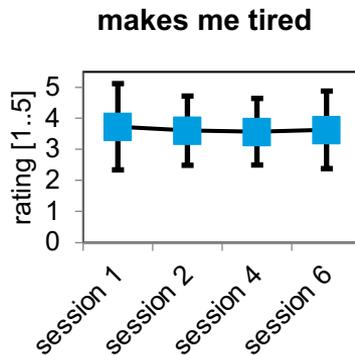
Results – Driver state changes

Indicator: Items from L3Pilot questionnaire

Results:

With repeated usage

- Stress decreases
- Workload decreases
- Reported fatigue decreases
- But: Fatigue ratings increase during automated drives



Results – Changes in trust and acceptance

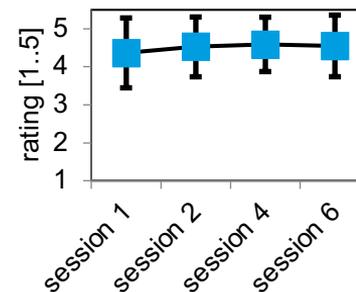
Indicator: Items from L3Pilot questionnaire
Proportion of time driving with activated ADF

Results:

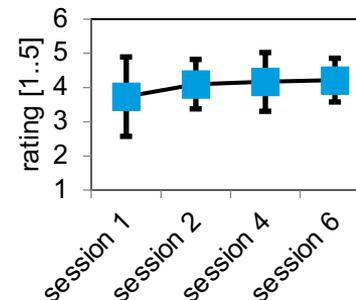
With repeated usage

- Trust increases
- Willingness to use increase
- There is no change of actual usage (overall high activation)

I would use ADF



I trust ADF



Results: Impact of ADS level

- L4 ADF was evaluated more positive than the L3 ADF
- Higher willingness to use for the L4 ADF
- With the L3 ADF, drivers spent more time on non-driving related activities, with the L4 ADF, drivers spent more time with their eyes closed.
- With L4 ADF, watching movies and sleeping are more popular non-driving related activities than with L3 ADF
- During drives with L4, drivers spent more time sleeping

Summary

- Overall positive evaluation of L3 and L4 ADF
- High usage throughout all drives
- Increase in acceptance and trust especially after the first encounter
- No critical take-over situations and no critical change in take-over performance
- Stress and workload decrease but fatigue might be increased by AD resulting in sleep-deprived drivers sleeping during the drive
- “first encounter”, “learning”, and “trust” phases seem to overlap



Thank you for your kind attention.

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