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LAB ACCIDENTOLOGIE, BIOMÉCANIQUE, COMPORTEMENT HUMAIN

The effects of mental workload and duration of automated driving on driver behaviour

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version 06/04/2017

CONTEXT

Automated driving =
Level 3 & 4 (SAE, 2014)

- Lateral control
- Longitudinal control
- Monitoring of driving environment

+ Drowsiness
- Situation awareness
+ Engagement in non-driving tasks

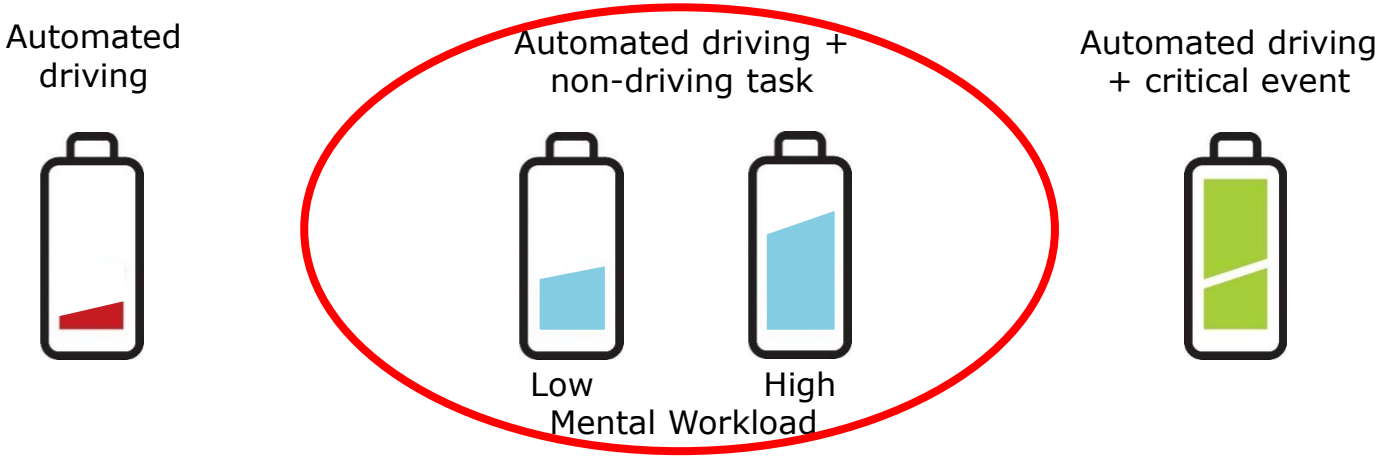
Impact on driver behaviour

However, drivers need to be available to take-over control of the vehicle

INTRODUCTION

MENTAL WORKLOAD

- **Automation results in an uneven distribution of mental workload**
- **Malleable Attentional Resources Theory (Young & Stanton, 2002) :** we adapt our attentional resources as a function of the task demands



→ How drivers react to a critical event depending on the level of mental workload?

INTRODUCTION

DURATION OF AUTOMATED DRIVING

- **Difference between short vs long exposure to the system (learning vs integration phase)**
- **Most studies analysed driver behaviour after short period of automated driving (10-15 min)**
- **→ Negative effect after longer vs shorter automated time period (Feldhütter et al., 2016)**

→ How drivers react to a critical event depending on the duration of automated driving?

OBJECTIVE

- **To analyse the effect of :**

1. **Different levels of mental workload (low vs high) related to a non-driving task**
2. **Duration of automated driving (10 vs 30 min)**

→ on driver performance during a take-over request

METHOD

- **Participants**

55 drivers (M = 35 years)

- **Apparatus**

VEDECOM driving simulator

- **Experimental design**

IV-1: Type of drive (x3)

- **M**anual **D**riving (**MD**)
- **A**utomated **D**riving + non-driving task & **L**ow mental workload (**AD-L**)
- **A**utomated **D**riving + non-driving task & **H**igh mental workload (**AD-H**)

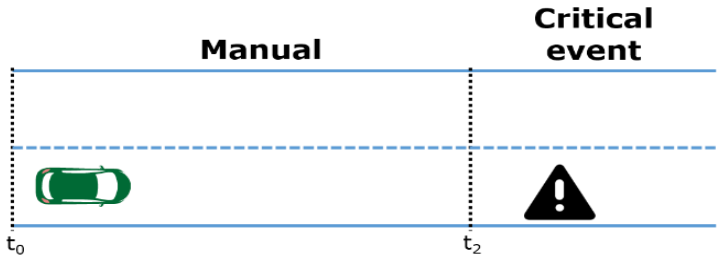
IV-2: Duration (x2)

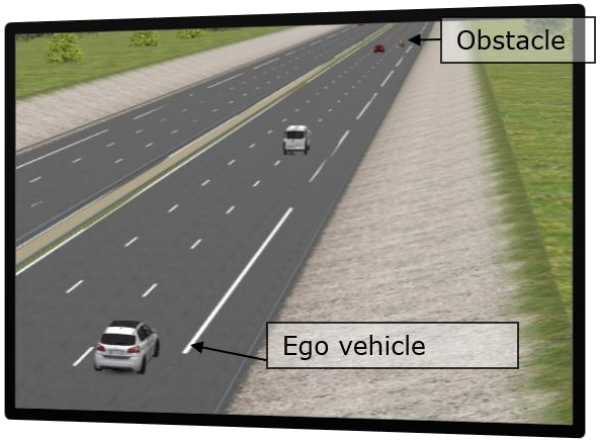
- 10 minutes
- 30 minutes

METHOD

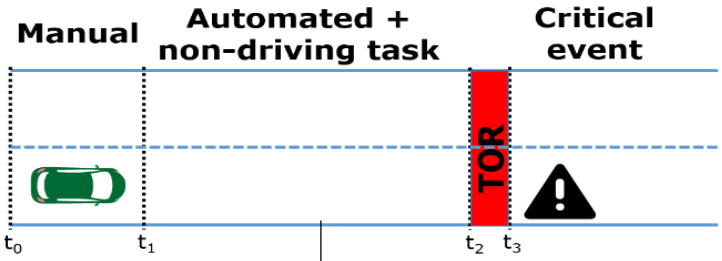
- **Scenarios**

- Manual Driving (MD)

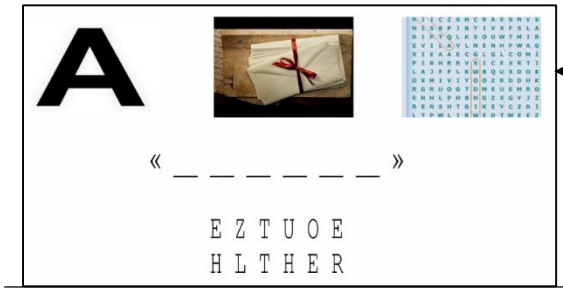




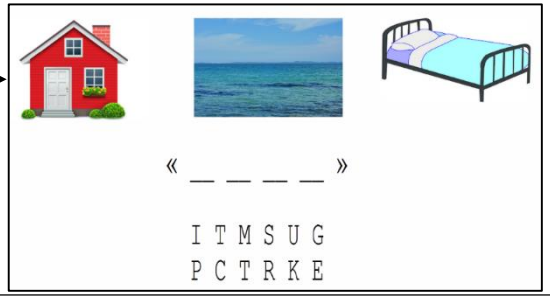
- Automated Driving



Low mental workload (AD-L)



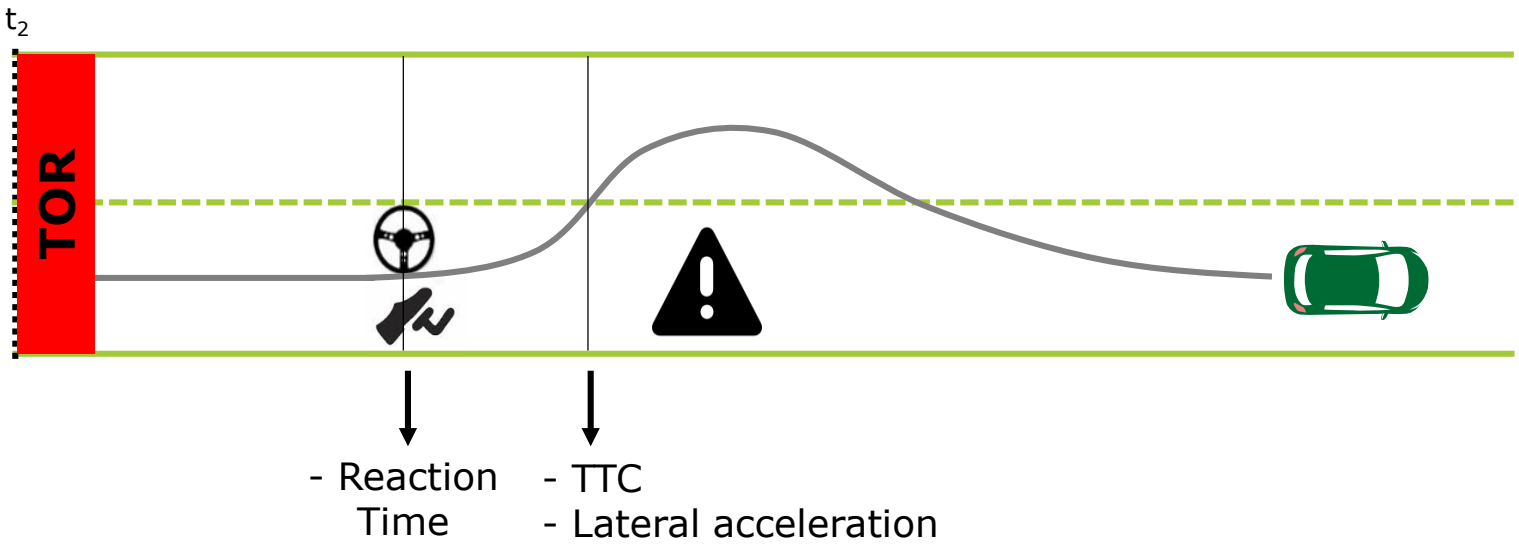
High mental workload (AD-H)



METHOD

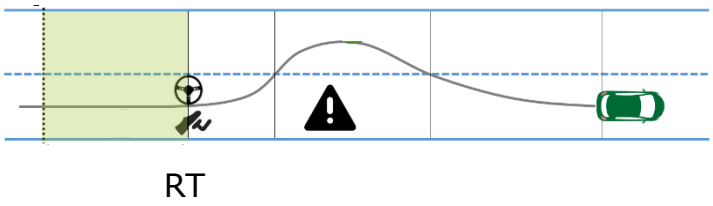
Driver performance:

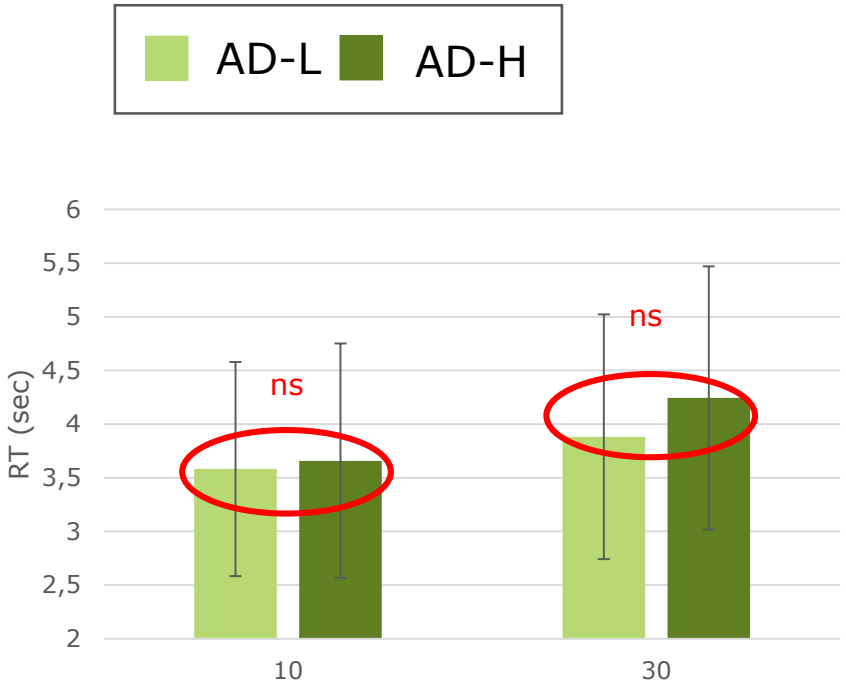
- Take-over reaction time
- Time-to-collision (TTC)
- Lateral acceleration



RESULTS

- **Take-over reaction time**





- No significant effect of the level of mental workload

Bueno, M. et al. (2016). *IEEE 19th ITSC*

RESULTS

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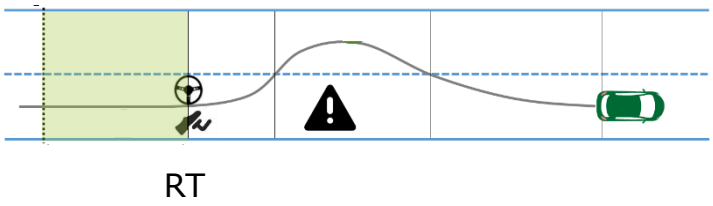
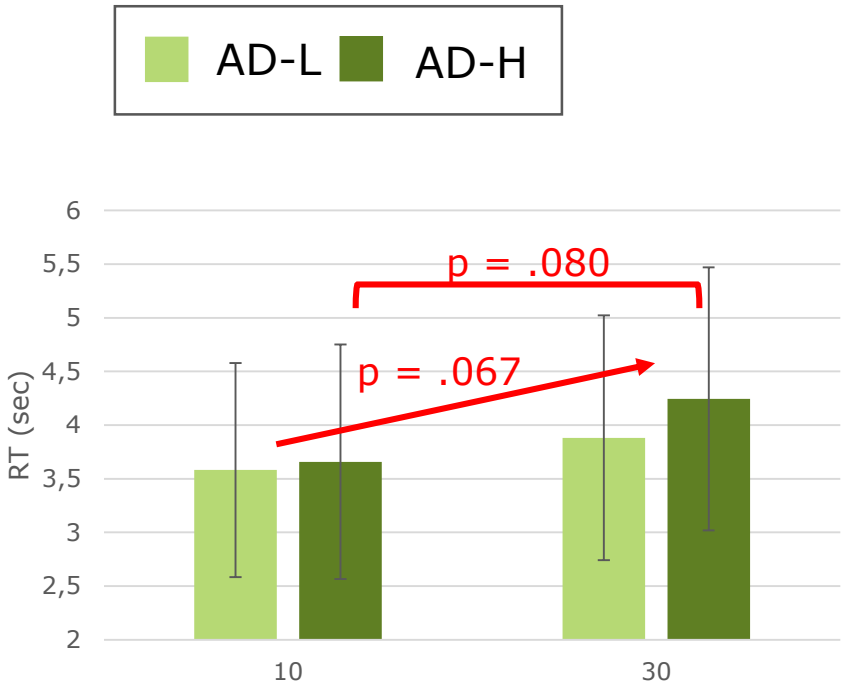




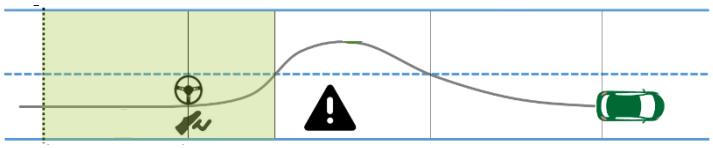
- No significant effect of the level of mental workload

- Tendency for drivers to react slower following a 30 min driving, especially when they were engaged in a more cognitive demanding activity (+ 440 ms)

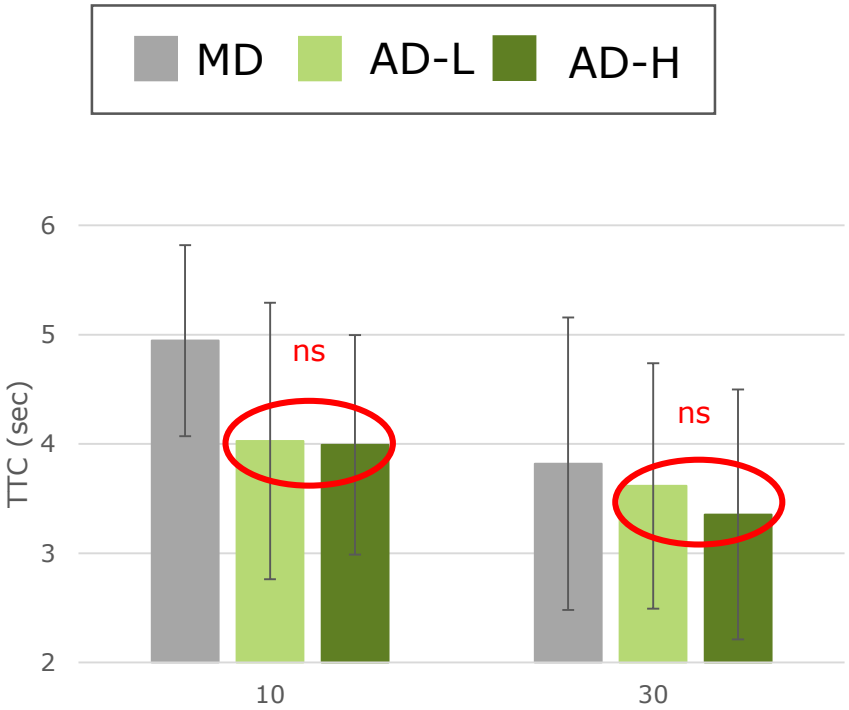
Bueno, M. et al. (2016). *IEEE 19th ITSC*

RESULTS

- **Time-to-collision (TTC)**



TTC



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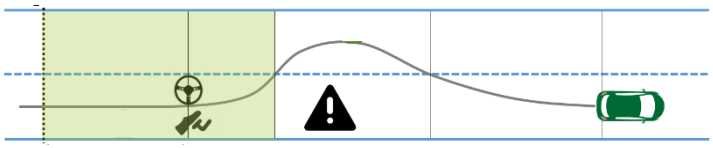
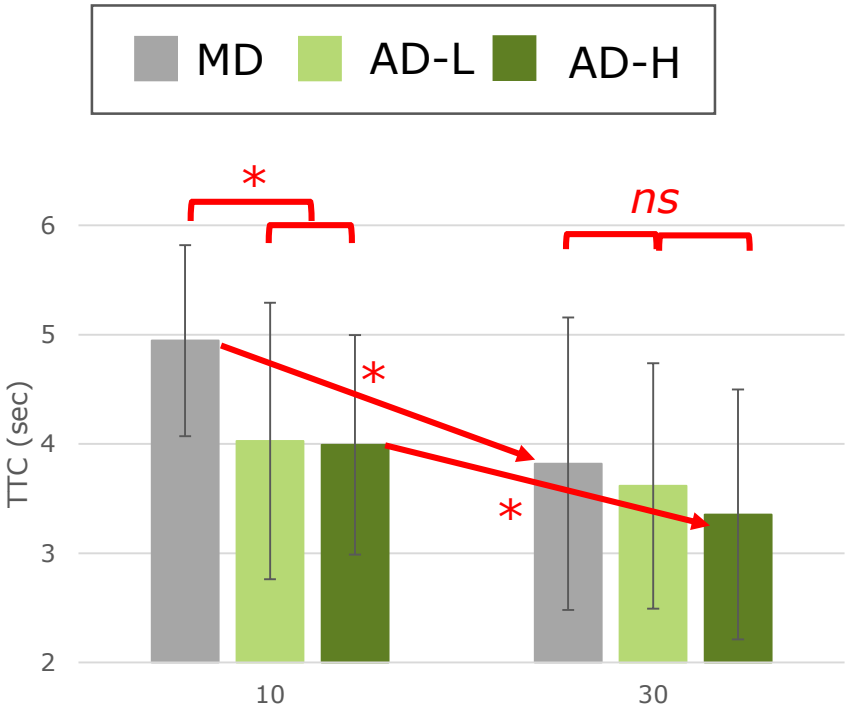


TTC



- No significant effect of the level of mental workload

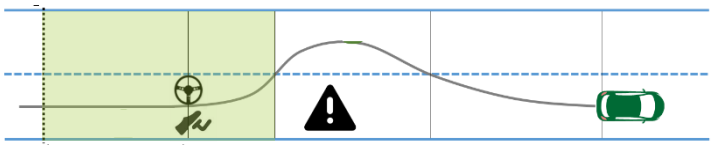
- The advantage of MD compared to AD disappeared after a longer duration of driving

- Negative effect of longer driving in MD and AD-H conditions but not in AD-L condition.

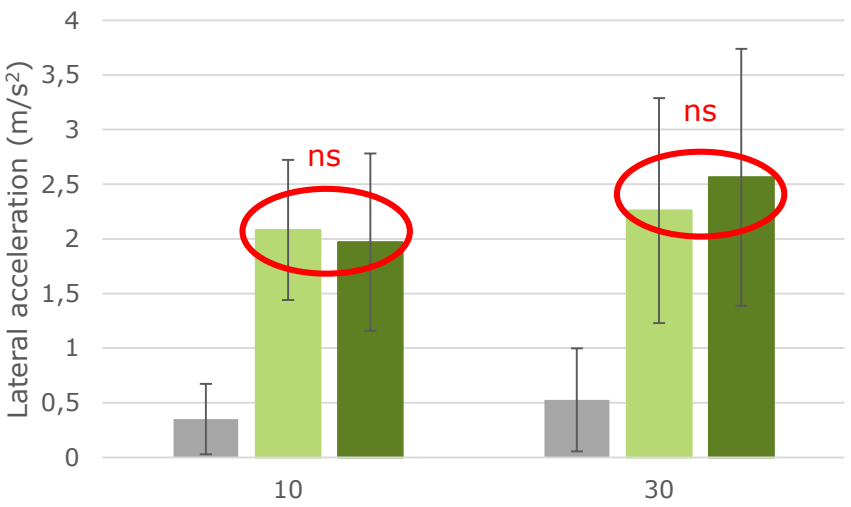
Bueno, M. et al. (2016). *IEEE 19th ITSC*

RESULTS

- **Lateral acceleration**



Lateral acceleration



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RESULTS

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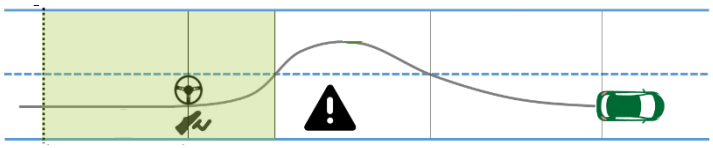
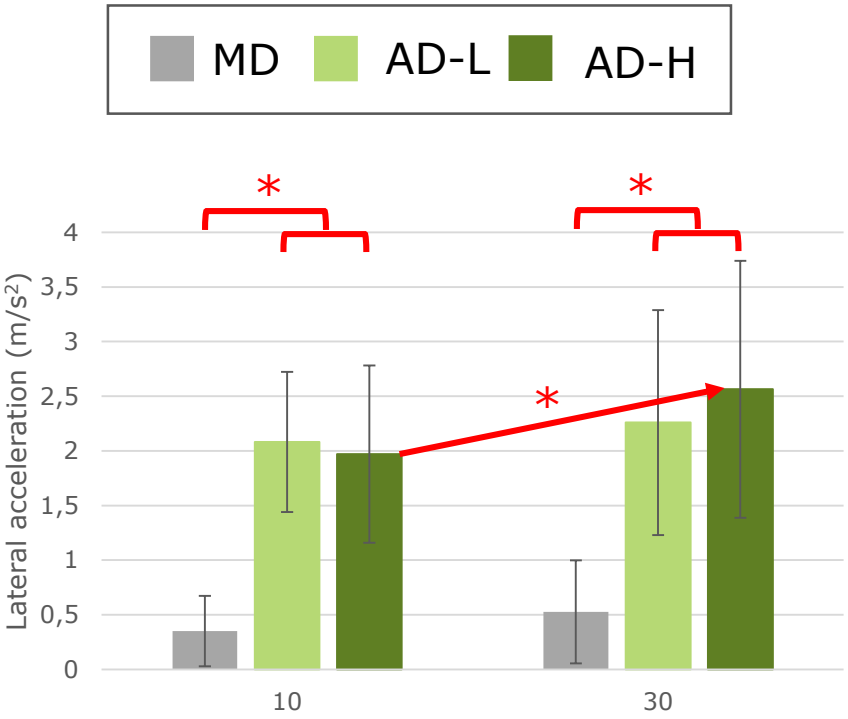


Lateral acceleration



- No significant effect of the level of mental workload

- Drivers performed more abrupt lateral manoeuvres in the AD condition than in the MD condition (5 times higher)

- Negative effect of longer driving in AD-H condition

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RESULTS

- **Subjective measures:**

- Drivers indicated more drowsiness after MD compared to AD
- Drivers evaluated MD as more discouraging, irritating and annoying than AD

CONCLUSION

- **Impact of mental workload (low vs high)**

- No effect of the level of mental workload

→ Other studies showed no differences between 2 different activities (Dogan et al., 2016; Radlmayr et al., 2014)

- **Impact of automation (manual vs automated)**

- Preference for AD but a negative effect on driver behaviour

→ Engagement in non-driving tasks could reduce situation awareness but also could reduce fatigue and increase alertness (Neubauer et al., 2012)

- **Impact of duration of AD (10 vs 30)**

- Negative effect of longer driving (Feldhütter et al., 2016)
  - Particularly after engaging in a more demanding task
  - The advantage of MD can disappear
  - Protective effect of low demanding tasks against fatigue?

Thank you for your attention