

Comparing different types of track side view in high speed train driving

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Knowledge for Tomorrow



Future High Speed Train Operation – Aims and Ambitions

- **Main goal for high speed (HS) train operation by EU Commission until 2050:**
 - „Majority of medium distance passenger transport by rail“ (<1000 km)
- **Attaining these goals is likely to require automatic train operation (ATO)**



Job Characteristics under ATO

• Information Environment:

- All relevant **train parameters** are displayed on the European Train Control System- Driver-Machine Interface (ETCS- DMI) e.g. speed, traction
- All relevant **operational information** is in the cabin as well e.g. schedule, radio
- So the vast majority of relevant information is being displayed **in the cabin**



• Tasks of the train driver in ATO (Brandenburger et al. 2016)

- Basically a classical vigilance task monitoring the ATO
- Detection of disparity between train behaviour and display information
- Communication (with staff and passengers)



Constructs of Interest in the ATO Context

- **Situation Awareness:**

- SA is critical to the monitoring task
- The driver needs to anticipate important future points of braking and verify the correct execution.
- Earlier findings suggest that increased automation leads to degraded mental models and SA (e.g. Kaber & Endsley, 2004)

- **Visual Attention:**

- Perception of relevant information through visual attention is the key to SA Level 1 (Parasuraman, Sheridan & Wickens, 2008)
- Therefore, driver needs to continuously attend to the in-cabin displays
- Increased automation in train driving was found to lead to a shift of the driver attention onto the in-cabin displays (Dietsch & Naumann, 2015)



Research Questions

- Can we avoid SA losses in the ATO context by focusing the visual attention on the relevant information on the ETCS- DMI?
- Can we direct visual attention onto the ETCS- DMI by minimizing other information sources like the track side view?



Variables to be Examined

- **Dependent Variables:**

- Situation Awareness:

- Situation Awareness Rating Technique SART (subjective measure)
 - Situation Present Assessment Method SPAM (objective measure)

- Visual Attention

- Eyetracking: Number of Fixations on DMI

- **Independent Variables:**

- Train driving (Manual/ ATO) between- subject
 - View (Regular/Monitor-sized/ No view) within- subject



Future High Speed Train Operation - Hypotheses

- **Visual Attention:**

- H1: We expect the **number of fixations** on the DMI to be **higher** in the **ATO condition** (Dietsch & Naumann, 2015)
- H2: We expect the **number of fixations** on the DMI to **increase with decreasing size** of the track side view

- **Situation Awareness**

- H3: We expect the **situation awareness** measures to be **smaller** in the **ATO condition** (Kaber & Endsley, 2004)
- H4: We expect the **situation awareness** measures to **increase with decreasing size** of the track side view



Future High Speed Train Operation - Experimental Setup

• Simulator Experiment:

- Sample: 26 male german train drivers
 - Mean age = 36.53 (SD = 10.92)
 - Mean occupational experience in years = 14.07 (SD = 10.85)
- 2*3 mixed repeated measures design
 - between- subject ATO * within- subject Track side view size
- Total driving time in the “RailSet Simulator” was 105 minutes (**three blocks** à 35 min.)

ATO	Track side view		
ATO	Regular	No	Monitor
Manual	No	Monitor	Regular



Future High Speed Train Operation – Results Visual Attention

- **H1: Number of fixations higher in ATO condition**

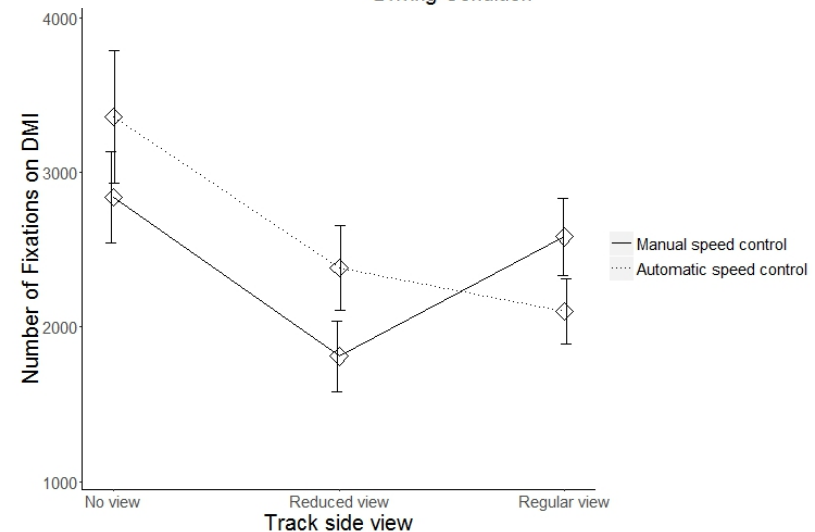
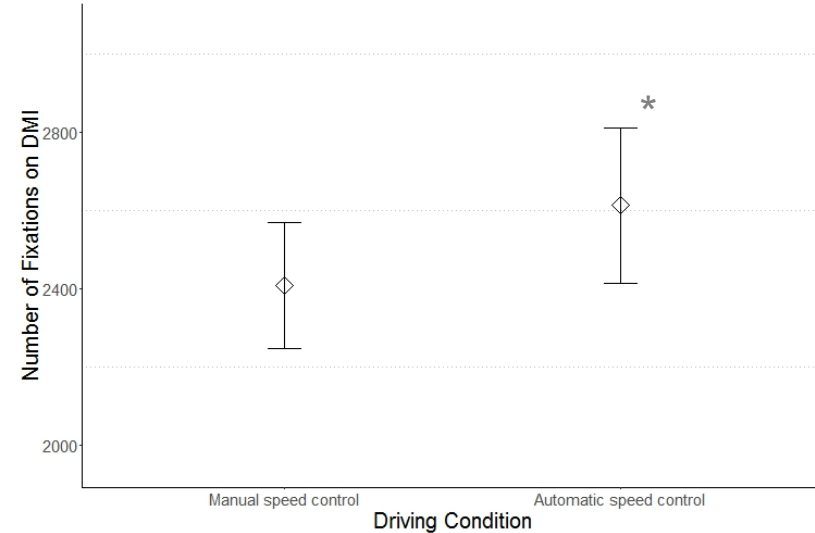
- Data shows an according trend but not significant at .05

X

- **H2: Number of fixations higher when track side view small**

- Highly significant (.01) effect of track side view size ✓
 - Although manual /regular view deviates from this H2 effect there was no significant interaction undermining H2.

* Error bars represent the Standard Error of the mean



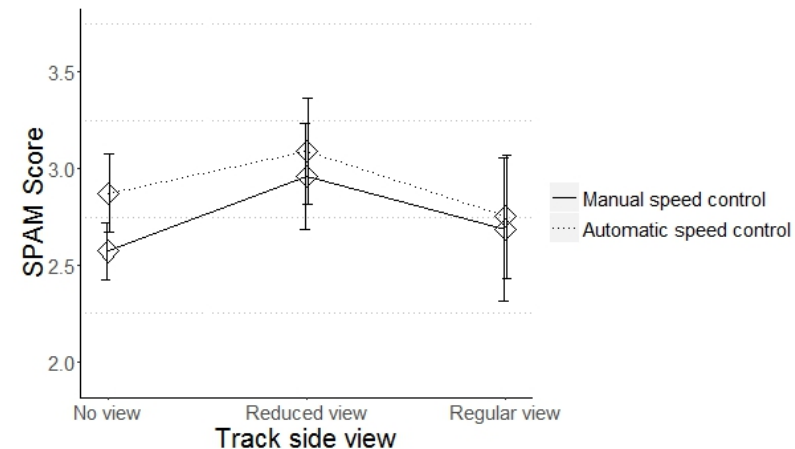
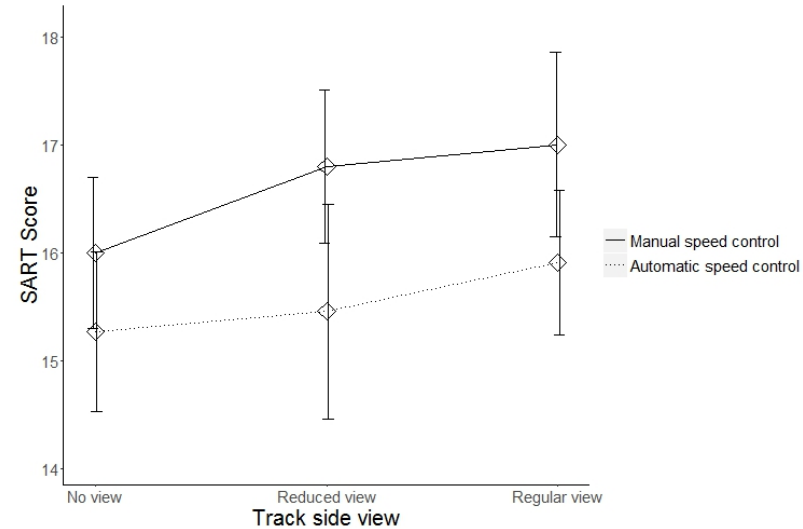
Future High Speed Train Operation – Results Situation Awareness

• H3: Situation Awareness smaller in ATO condition

- H3: No significant (.05) effect in subjective (SART) or objective (SPAM) data **X**
- Interesting: subjective situation awareness is worse / objective situation awareness is better in ATO condition
- Pearson correlation (SPAM,SART) = .34

• H4: Situation Awareness bigger when track side view small

- H4: No significant (.01) effect of track side view size **X**
- Subjective situation awareness even slightly increases/ objective situation awareness mainly unchanged



Future High Speed Train Operation - Conclusions

- **Visual Attention:**

- Although not significant at .05 the data shows the known tendency that more automation functionality in the cabin leads to more visual attention on these displays (H1)
- The visual attentional focus can be directed to the DMI by shrinking the track side view (H2)
- Not providing a track side view at all, may lead to adverse effects (acceptance measures, fatigue, monotony)

- **Situation Awareness:**

- Both subjective and objective situation awareness are neither influenced by automation functionality nor by size of the track side view in our sample (H3/H4)
- Especially objective situation awareness is very robust and does not seem to benefit from larger track side view



Thank you very much for your interest in our research!

Questions, Remarks or Suggestions

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Knowledge for Tomorrow



Future High Speed Train Operation - Future Research

- **Finding the right size for the track side view to support effective visual monitoring**

Our long term goal

- **Defining a remote control environment for automated HS trains that allows effective part - time monitoring of critical manoevers and system failures by**
 - Ensuring effective visual attention allocation
 - supporting fast situation awareness build up
 - minimizing the monotonous / continuous vigilance part of the task



Future High Speed Train Operation - Lessons Learned

- Complex mixed effect models are not backed up by enough sample data to satisfy inferential alpha levels of .05
- Negative effects of automation may be less pronounced, because the difference in task load between conditions is smaller than in e.g. aviation or ATC
- Additionally, train drivers may be used to an more robust to these underload conditions

