The Influence of Interface Design on Driver Behavior in Automated Driving

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Transport Canada

28th CARSP Conference, Victoria, BC, June 10-13, 2018
Human Factors Research for Automated Vehicles

HMI for Automated Driving Systems (ADS):

What information is needed by the driver?
How is this best presented for safe and efficient performance?

ADS supervision of the driver & bringing driver back in the loop:

What do vehicles need to monitor about the driver?

Interactions of other road users and ADS:

Do automated vehicles need additional External displays?
What do they need to display?

How can we evaluate the effectiveness and safety of ADS displays?
Need a toolkit of Human Factors design procedures and assessment methods

Design Process Requirements

Expert Audit

Lab Testing

Field Operational Trials
Transport Canada AV Interface Study

- Automated driving system mode/status displays vary in their content, salience and utility
- Research suggests design of current status displays can problematic (e.g., Dikman & Burns, 2016; Endsley, 2017)
  
  Poorly understood, mode confusion...

- How do we evaluate them?
Current Focus: System Initiated Request to Intervene

[Graph showing lane position over time with interface change at time 6 and 12.]
Method

Data collection:
- MiniSim driving simulator
- Video Recordings
  (4 camera infrared DVR system)

Participants:
- \( N = 32 \) (18 male, 14 female)
- Age: 20 – 58 (\( M = 34.5, \ SD = 9.27 \))

Approach:
- Examine how two interface designs that differed in colour, intensity, size, location, presentation, and content influences driving performance in a conditionally automated driving system
Procedure:

• Participants engaged an automated driving system on a 4-lane divided highway.

• L3 with set speed of 100 km/h and Lane-Keeping

• Performed a continuous secondary dot-counting task
Events that Exceed System Operational Limits

1. Construction Zone
2. Vehicle Cut-in
3. Parked Vehicle
4. Red-light Stopped Vehicle
5. Vehicle Merge-in
6. Slow Moving Vehicle
Events that Exceed System Operational Limits

- Construction Zone
- Vehicle Cut-in
Dependent Measures

Simulator Measures
- Driver initial response to interface alert from 6s TTC
  - First of:
    - Accelerator pedal depression
    - Brake pedal depression
    - Steering wheel movement

Video Measures (reduction from 6s TTC)
- Task disengagement time
- Hands-on-wheel time
- Initial steering movement
Results: Construction Zone

- Simple Interface
- Advanced Interface

<table>
<thead>
<tr>
<th>Task Disengagement</th>
<th>Time (s)</th>
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<tbody>
<tr>
<td>Simple Interface</td>
<td>5</td>
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<tr>
<td>Advanced Interface</td>
<td>3</td>
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<table>
<thead>
<tr>
<th>Interface Alert Response</th>
<th>Time (s)</th>
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<td>Simple Interface</td>
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<td>Advanced Interface</td>
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<thead>
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<th>Hands-on-wheel</th>
<th>Time (s)</th>
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<td>Advanced Interface</td>
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<table>
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<tr>
<th>Initial Steering Movement</th>
<th>Time (s)</th>
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<tr>
<td>Simple Interface</td>
<td>4</td>
</tr>
<tr>
<td>Advanced Interface</td>
<td>2</td>
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</tbody>
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* p < 0.05  

n.s. – non-significant
Results: Vehicle-cut in

- Interface Alert Response
- Task Disengagement
- Hands-on-wheel
- Initial Steering Movement

Simple Interface vs. Advanced Interface

* p < .05
Next Steps

- Continue data analyses – focusing on the quality of the takeover performance and other measures
- Further development of testing methods & scenarios in support of ISO
The Interaction between driver and vehicle is especially important for ADS

Well designed, effective and safe HMI is required to address challenges

- Keeping/bringing drivers-in-the-loop
- Driver distraction, confusion and overload; monotony
- Unintended consequences, trust and acceptance

Vital need to use effective HMI design practices in development and evaluation procedures for identifying and addressing risks.

New human factors design procedures and metrics are likely needed to meet these new challenges.
Thank you!

Questions?

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