Ambient light based interaction concept for an integrative driver assistance system

EU Project AdaptIve

Marc Dziennus
Johann Kelsch
Anna Schieben

International Conference on Traffic and Transport Psychology
Brisbane 16/08/5
AdaptlVe
Automated Driving

Budget: 25 Million EUR
European Commission: 14.3 Million EUR

Duration: 42 months
(January 2014 – June 2017)

Coordinator: Aria Etemad,
Volkswagen Group Research

28 Partner: France, Germany, Greece, Italy, UK
Spain, The Netherlands, Sweden
Levels of automation in AdaptIVe

SAE

SAE document J3016, "Taxonomy and Definitions for Terms Related to On-Road Automated Motor Vehicles", issued 2014-01-16
Motivation:

- Highly automated driving requires reliable sensor data
- If sensors deliver doubtful information or traffic situations were unclear
Levels of automation
Role of the driver

LDW FCW
level 0
No automation

LKA ACC
level 1
Assisted

Parking Assistance
level 2
Partial automation

Traffic Jam Chauffeur
level 3
Conditional automation

Parking Garage Pilot
level 4
High automation

Robot Taxi
level 5
Full automation

Adaptive levels of automation
Problem description

Problem:
- Too frequent transitions lead to fewer acceptance of highly automated driving

Solution:
- In uncertain situations, bring the driver into a monitoring role (SAE level 2)
Problem description

**Problem:**
- Too frequent transitions lead to fewer acceptance of highly automated driving

**Solution:**
- In uncertain situations, bring the driver into a monitoring role (SAE level 2)
Research Question

1. How can we bring the driver from level 3 into a monitoring role (SAE level 2)?
   → Ambient Light

- Information via peripheral vision
- Directed information about environment
Research Question

1. How can we bring the driver from level 3 into a monitoring role (SAE level 2)?
   → Ambient Light

- Information via peripheral vision
- Directed information about environment
- Warnings
Research Question

1. How can we bring the driver from level 3 into a monitoring role (SAE level 2)?
   → Ambient Light

- Information via peripheral vision
- Directed information about environment
- Warnings
- Recommendations
Research Question

1. How can we bring the driver from level 3 into a monitoring role (SAE level 2)?
   → Ambient Light

- Information via peripheral vision
- Directed information about environment
- Warnings
- Recommendations
- Automation level
Research Question

2. Can specific information about tracked vehicles on the ambient light help the to anticipate critical situations?
   - Understand automation maneuvers?
   - Can automation failures be foreseen?
Dynamic driving simulator

40 Participants
20♀ 20♂
**Experimental design**

<table>
<thead>
<tr>
<th>Automation can handle situation</th>
<th>Indication of tracked vehicle on LED</th>
<th>No indication of tracked vehicle on LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indication</td>
<td>No indication</td>
<td>No indication</td>
</tr>
<tr>
<td>No indication</td>
<td>No indication</td>
<td>No indication</td>
</tr>
</tbody>
</table>

Between subject design
Uncertainty Feedback
Design for SAE Level 2

- Indication of detected vehicle
  - Ambient light with indication of detection vs.
  - Baseline with no further information

Design 1: Without indication
Design 2: With indication
Design for SAE Level 2
## Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainty Feedback</td>
<td>x</td>
</tr>
<tr>
<td>Indication of tracked vehicles</td>
<td>x</td>
</tr>
<tr>
<td>Automation reacts correct</td>
<td>√</td>
</tr>
</tbody>
</table>

**SAE 3**
## Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Type II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainty Feedback</td>
<td>x</td>
<td>√</td>
</tr>
<tr>
<td>Indication of tracked vehicles</td>
<td>x</td>
<td>√</td>
</tr>
<tr>
<td>Automation reacts correct</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

![SAE 3 diagram](#)
## Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Type I</th>
<th>Type II</th>
<th>Type III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainty Feedback</td>
<td>x</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Indication of tracked vehicles</td>
<td>x</td>
<td>√</td>
<td>x</td>
</tr>
<tr>
<td>Automation reacts correct</td>
<td>√</td>
<td>√</td>
<td>x</td>
</tr>
</tbody>
</table>
Scenarios

1. Uncertainty feedback
2. Situational change after 15 seconds
Data is not completely analyzed..

First results
Results

Question:

1. How can we bring the driver from level 3 into a monitoring role (SAE level 2)?

Answer:

- Gaze behavior changed after uncertainty Feedback (both designs)
  - Drivers focus the street significantly more $t_{(31)} = -4.017$, $p < 0.001$
Results

Question:

- Can specific information about tracked vehicles on the ambient light help the to anticipate critical situations?
  - Understand automation maneuvers?

Answer:

- No significant difference regarding early takeovers between the groups
Results

Number of early Takeover

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Uncertainty feedback</th>
<th>Uncertainty feedback + Automation view</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>
Results

Question:

- Can the Ambient Light help drivers to anticipate automation behavior?
  - Can automation failures be foreseen?

Answer:

- Significant differences regarding distance to front vehicle at takeover
  $F_{(37)} = 3.94, p=0.04$
    - Takeovers at a higher distance with indication of detected vehicles
Conclusion

- Ambient Display is effective in bringing drivers back into a monitoring role
  - Change in gaze behavior

- If feedback on detected vehicles via the Ambient Light helps to anticipate automation behaviour needs further exploration
Outlook

• Exploration of the ambient light in a test vehicle
  • Ongoing

• Exploration of ambient light for automated vehicles in urban scenarios
Thank you very much for your attention

Marc Dziennus
marc.dziennus@dlr.de

Johann Kelsch
johann.kelsch@dlr.de

Anna Schieben
anna.schieben@dlr.de