Age-specific Contact Analogue Head-up Displays: Will They Be Accepted By Older Drivers?

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Introduction

Assistance of Older Drivers by Augmented Reality (AR)

Traffic-related changes due to aging processes concerning...
- Perception
- Cognition
- (Motor reaction)

Negative impact on driving performance, especially in complex, dynamic traffic situations
(Buld, Hoffmann, & Krüger, 2006; Clarke, Ward, Bartle, & Truman, 2010)

Compensation by augmented reality displays (ARD)
- No unnecessary glances away from the street (Medenica, Kun, Paek, & Palinko, 2011)
- No additional need to focus on different sources of information (Kim & Dey, 2009)
- Facilitated information processing due to intuitive presentation (Kim & Dey, 2009)
Acceptance of New Technologies among Older Drivers

- Age-specific acceptance barriers
  - Reduced willingness to use new in-vehicle information systems, compared to younger drivers (Lerner, Singer, & Huey, 2008)
  - Mismatch between the current older generation’s mechanical understanding of technology and restricted influence possibilities of electronic systems (Jakobs, Lehnen, & Ziefle, 2008)

- Older drivers’ acceptance of a system depends on its perceived usefulness (Jakobs et al., 2008)

- Perceived usefulness is affected by design aspects (Ziefle, Pappachan, Jakobs, Christen, & Wallentowitz, 2007)

- Requirements of older drivers’ acceptance of an ARD:
  - Compensation of age-related driving difficulties
  - Information design in consideration of age-specific changes in perception and cognition
Concept for an Age-specific Augmented Reality Display (ARD)

- **Use case:** intersection as most difficult traffic situation (Kocherscheid & Rudinger, 2005)
- **Displaying the upcoming priority regulation to solve age-specific reasons for priority errors, e.g.:**
  - Difficulties with perceiving traffic signs (Bayam, Liebowitz, & Agresti, 2005)
  - Difficulties with decision-making under time pressure (Kocherscheid & Rudinger, 2005), e.g. regarding right of way (Staplin & Fisk, 1991)
Research Questions

- Are older drivers willing to use an ARD with an age-specific content and design?
  - If necessary: Which aspects need to be improved to increase their acceptance?

- As younger drivers could also benefit (to a lesser degree) from this ARD: Would they accept an age-specific system or refuse to use it?
## Experimental Design

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Younger Drivers (25 – 45 years old)</th>
<th>Older Drivers (65 – 80 years old)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent Variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No ARD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARD&lt;sub&gt;short&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARD&lt;sub&gt;long&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### ARD Condition
- **No ARD** (control group)
- **ARD<sub>short</sub>** (experimental group 1)
- **ARD<sub>long</sub>** (experimental group 2)

**Note:** The figure shows the experimental setup with distances of 150 m, 75 m, and 0 m.
## Participants (N = 117)

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Younger Drivers</th>
<th>Older Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>M&lt;sub&gt;age&lt;/sub&gt;</td>
</tr>
<tr>
<td>No ARD (control group)</td>
<td>18</td>
<td>28.7</td>
</tr>
<tr>
<td>ARD&lt;sub&gt;short&lt;/sub&gt; (group 1)</td>
<td>15</td>
<td>28.7</td>
</tr>
<tr>
<td>ARD&lt;sub&gt;long&lt;/sub&gt; (group 2)</td>
<td>19</td>
<td>30.0</td>
</tr>
<tr>
<td>Total</td>
<td>52</td>
<td>29.2</td>
</tr>
</tbody>
</table>
Apparatus and Driving Scenario

- Driving simulator study
  - Fixed-base driving simulator
  - 180° field of view
  - SILAB simulation software

- Urban test track
  - 9 km long
  - 13 intersections with different priority regulation, course of the lanes and traffic density
  - Simulated ARD for experimental group 1 (ARD_{short}) and 2 (ARD_{long})

- Driving task: driving towards the city of Chemnitz (following directions signs)
Assessment of Drivers’ Acceptance

Van der Laan acceptance scale (Van der Laan, Heino, & De Waard, 1997)

- Attitudes towards the age-specific ARD
- Nine items, for example:

  I think the ARD is... (please tick a box in every line)

  useful □ □ □ □ □ □ useless

- Presented after the test drive to all three ARD groups
  - Experimental group 1 (ARD\textsubscript{short}) and 2 (ARD\textsubscript{long}): Evaluation of system experience
  - Control group (no ARD): evaluation of system concept without actual experience
Assessment of Drivers’ Acceptance

Unified Theory of Acceptance and Use of Technology (UTAUT) questionnaire (Venkatesh, Morris, Davis, & Davis, 2003) (German adaptation)

- Eight scales to predict expected use behaviour
  - Performance expectancy
  - Effort expectancy
  - Social influence
  - Behavioural intention to use
  - Facilitating conditions
  - Use behaviour
  - Anxiety
  - Self-efficacy
  - Attitude towards using

- Thirty-one items, for example:
  
<table>
<thead>
<tr>
<th>I feel apprehensive about using the system.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
</table>

- Presented after the test drive to experimental group 1 (ARD_{short}) and 2 (ARD_{long})
Results

Cronbach’s α = .93 (nine items)

Positive evaluation by both age groups in all ARD conditions

Significant higher ratings of older drivers, \( F(1, 107) = 4.04, p = .047, \eta^2_p = .04 \).
UTAUT Questionnaire

- Significant higher ratings of older drivers, Pillai’s trace criterion = .36, $F(8, 66) = 4.69$, $p < .001$, $\eta^2_p = .36$. 

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**ARD**

<table>
<thead>
<tr>
<th>Behavioural intention to use</th>
<th>Old drivers</th>
<th>Young drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitating conditions</td>
<td>Old drivers</td>
<td>Young drivers</td>
</tr>
<tr>
<td>Performance expectancy</td>
<td>Old drivers</td>
<td>Young drivers</td>
</tr>
<tr>
<td>Effort expectancy</td>
<td>Old drivers</td>
<td>Young drivers</td>
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<tr>
<td>Social influence</td>
<td>Old drivers</td>
<td>Young drivers</td>
</tr>
<tr>
<td>Attitude towards using</td>
<td>Old drivers</td>
<td>Young drivers</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>Old drivers</td>
<td>Young drivers</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Old drivers</td>
<td>Young drivers</td>
</tr>
</tbody>
</table>

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* Significant at the 0.05 level.
** Significant at the 0.01 level.
*** Significant at the 0.001 level.
Evaluation of an Age-specific ARD by different Age Groups

- Positive Evaluation of the ARD among both age groups

- Older drivers showed a significant...
  - Better attitude towards the ARD and its usage
  - Higher believe that their driving performance will benefit from using the ARD
  - Higher intention to use the ARD

- Significant lower ratings of older drivers concerned other usage aspects than system characteristics
  - Facilitating conditions → environmental factors
  - Self-efficacy → intrapersonal factors
Conclusions

- Older drivers are willing to use new technologies like ARD, if they are adapted to their requirements
  → Necessary precondition of usage given
- Age-specific systems are not rejected by younger drivers, who could also benefit from their usage

Recommendations

- To increase drivers’ willingness to use age-specific assistance systems:
  - Consider specific design requirements
  - Take account of environmental and intrapersonal acceptance barriers (e.g. training)
  - Involve younger drivers via adaptive driver assistance systems
- For a better understanding of older drivers’ preferences: research on age-specific determinants of acceptance of driver assistance systems
Acknowledgements

This research is supported by funds of the European Social Fund (ESF) and the Free State of Saxony.

Thank you for your attention!

Ageing and Safe Mobility · Bergisch-Gladbach · 27th November 2014 · Franziska Hartwich


