Age & Gender Differences in the Acceptance and Effectiveness of Intelligent Warning Systems

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Automakers provide more and more intelligent driver assistance services

To meet consumers’ desire to extend their connected lifestyle

Acceptance of new technology is vital for implementation success

This study investigated the impact of intelligent warning systems on driving behavior related to safe driving through on-road experiments
The Highway Loss Data Institute (HLDI) reported

- Forward collision avoidance systems show the biggest crash reductions
- Lane departure warning (LDW) appears to hurt, rather than help
- The opposite of LDW’s intended effect can be caused by driver’s lower acceptance due to some reasons such as frequent false alarms and unpleasant warning sound

Technology acceptance & effectiveness may vary by gender & age
Participants overview

<table>
<thead>
<tr>
<th></th>
<th>Younger</th>
<th></th>
<th>Late Mid Age</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
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<tr>
<td># Subject</td>
<td>13</td>
<td>13</td>
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<tr>
<td>Age</td>
<td>27.5 (2.9)</td>
<td>30.5 (3.1)</td>
<td>60.7 (1.9)</td>
<td>57.1 (2.1)</td>
</tr>
<tr>
<td># ADAS</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

Experimental Setup

- Front-view Camera
- Driver-view Camera
- Rear-view Camera
- On-Board PC
- ADAS Forward Collision & Lane Departure Warning
- Driver’s gaze measurement
- Vehicle Data via CAN (Accel., Brake, Steering Angle, Turn Signal, Velocity, RPM, etc.)
- In-vehicle Monitoring System
  - Physiological Data Measurement (ECG, Skin Conductance, Skin Temp, Respiration)
Intelligent Warning System: Mobileye C2-170 (The Netherland)

- **Forward Collision Warning feature** warns when approaching a preceding vehicle with a high closing rate (e.g. TTC≤0.6)
- **Lane Departure Warning feature** warns if the vehicle deviates or is about to deviate outside the lane

< Forward Collision Warning >  < Lane Departure Warning >
Experimental Procedure

- Informed consent
- Pre-questionnaire for driving safety
- On-road driving sessions
- Post-questionnaire for ADAS

Questions: 1-to-7 rating scale

<table>
<thead>
<tr>
<th>Categories</th>
<th>Question Items</th>
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<tbody>
<tr>
<td>Positive</td>
<td>Perceived Safety</td>
</tr>
<tr>
<td></td>
<td>Preference</td>
</tr>
<tr>
<td>Negative</td>
<td>Inconvenience</td>
</tr>
<tr>
<td></td>
<td>Annoyance</td>
</tr>
</tbody>
</table>

Experimental Routes

- Urban (7.9Km, 25min)
- Highway (10.4Km, 10min)
- Rural (5.5Km, 10min)
- Adaptation (11.5Km, 20min)
Independent Vars. for Effectiveness

- Forward collision warning
  - Average Velocity & Average Headway
- Lane departure warning
  - S.D. of Lane Position & Steering wheel Reversal Rate (#/min)

Statistical Analysis

- Comparisons of the effectiveness measures
  - Comparisons were made using a general linear model (GLM)
- Acceptance questionnaire measures
  - Comparisons were made using Kruskal-Wallis test.
    (Non-parametric equivalent of ANOVA)
Technology Acceptance Model (TAM) (Davis, 1989)

- Acceptance ($A$) = Perceived Usefulness ($U$) + Ease of Use ($EOU$)

**Age & Gender Differences in Attitude towards ADAS**

- Perceived Usefulness $\rightarrow$ Perceived Safety
- Ease of Use $\rightarrow$ Opposite of Inconvenience & Annoyance

### RESULTS: Age & Gender Differences

<table>
<thead>
<tr>
<th>Questions</th>
<th>Forward Collision Warning</th>
<th>Lane Departure Warning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Male: 6.00 (1.00) Female: 4.83 (1.47)</td>
<td>Male: 5.50 (1.87) Female: 4.86 (1.21)</td>
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<tr>
<td></td>
<td>Male: 5.29 (1.89) Female: 4.83 (1.17)</td>
<td>Male: 5.67 (0.82) Female: 5.14 (1.21)</td>
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<tr>
<td>Preference</td>
<td>Male: 5.71 (0.95) Female: 4.17 (1.17)</td>
<td>Male: 4.83 (2.04) Female: 4.71 (1.80)</td>
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<tr>
<td></td>
<td>Male: 4.71 (2.06) Female: 4.50 (1.38)</td>
<td>Male: 5.67 (0.52) Female: 5.57 (1.81)</td>
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<td>Inconvenience</td>
<td>Male: 3.00 (1.41) Female: 4.17 (0.75)</td>
<td>Male: 3.00 (2.10) Female: 3.71 (1.38)</td>
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<tr>
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<td>Male: 3.43 (1.90) Female: 4.83 (0.75)</td>
<td>Male: 3.33 (1.37) Female: 3.43 (1.40)</td>
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<tr>
<td>Annoyance*</td>
<td>Male: 2.29 (0.95) Female: 3.67 (1.51)</td>
<td>Male: 1.67 (0.52) Female: 3.00 (1.41)</td>
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<tr>
<td></td>
<td>Male: 3.29 (1.70) Female: 4.17 (1.17)</td>
<td>Male: 1.83 (0.41) Female: 3.29 (1.60)</td>
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</table>
Highway Driving

### Results: Effectiveness of ADAS Warning

#### Forward Collision Warning

- **Average Velocity (Highway):**
  - Male
  - Female
  - Younger
  - LMA
  - Non-supported vs. ADAS-supported

#### Lane Departure Warning

- **S.D. Lane Position (Highway):**
  - Male
  - Female
  - Younger
  - LMA
  - Non-supported vs. ADAS-supported

- **Average Headway (Highway):**
  - Male
  - Female
  - Younger
  - LMA
  - Non-supported vs. ADAS-supported

- **Steering Reversal Rate (Highway):**
  - Male
  - Female
  - Younger
  - LMA
  - Non-supported vs. ADAS-supported
RESULTS: Effectiveness of ADAS Warning

Urban Driving

<Forward Collision Warning>

Average Velocity (Urban)

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<thead>
<tr>
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<td></td>
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S.D. Lane Position (Urban)

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<Lane Departure Warning>

Average Headway (Urban)

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Steering Reversal Rate (Urban)

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DISCUSSION

General understanding of the acceptance and the effectiveness

- Younger female group showed the lowest acceptance
- Younger and LMA male groups were more likely to accept the systems

Age difference

- LMA groups’ preference of LDW > That of Younger groups
  - Older driver’s diminished driving performance
    (Especially lateral control ability)
  - Son et al. reported that the older Korean participants drove with more variability in lane discipline.
  - LMA groups may have more interests and preference to the device to compensate their degraded ability
Effectiveness perspective

- FCW significantly impacted on headway safety margin and younger driver’s velocity on highway driving
  - FCW could be a useful device to enhance highway safety
- LDW seemed to slightly decrease lateral control performance on highway and significantly increased SRR on urban driving
  - The results that coincided with HLDI report [3]
  - Raised a question whether LDW can indeed enhance driver’s safety

In summary

- LDW showed the opposite effectiveness of its intention
- Younger female showed the lowest acceptance
  - it is essential to assess age and gender differences in effectiveness and acceptance of new in-vehicle technology for avoiding unexpected negative effects on a certain age and gender segment
Thank You For Your Attention!

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www.humanlab.kr