Driver Training for Vehicle Automation

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Collaborators on Safe-D UTC Project

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If you were to ask a safety professional how likely it is that an individual would read the owners manual upon getting an automobile, the answer would probably be “very low.” (Leonard, 2001)

<table>
<thead>
<tr>
<th>Respondents</th>
<th>All</th>
<th>None</th>
<th>Special Topics</th>
<th>Until Tired</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 25+</td>
<td>10</td>
<td>2</td>
<td>27</td>
<td>11</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>(20.00%)</td>
<td>(4.00%)</td>
<td>(54.00%)</td>
<td>(22.00%)</td>
<td></td>
</tr>
<tr>
<td>Age &lt; 25</td>
<td>12</td>
<td>13</td>
<td>115</td>
<td>38</td>
<td>178</td>
</tr>
<tr>
<td></td>
<td>(6.74%)</td>
<td>(7.30%)</td>
<td>(64.61%)</td>
<td>(21.35%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>22</td>
<td>15</td>
<td>142</td>
<td>49</td>
<td>228</td>
</tr>
<tr>
<td></td>
<td>(9.65%)</td>
<td>(6.58%)</td>
<td>(62.28%)</td>
<td>(21.49%)</td>
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</table>
Current Practice: Trial-and-Error

• Practice does not make perfect, practice makes habit.

• Trial-and-Error may be useful in certain aspects of AV training and in certain situations (e.g. when the vehicle is stationary)
  • System Activation/Deactivation

• Safe operation of AVS requires a deeper understanding of the technology
How do drivers want to learn?

**Younger Drivers**
- Want to learn:
  - In-vehicle video
  - Gamification
  - Vehicle training mode
  - Video at Dealership
- Do not want to learn:
  - Classroom setting
  - DMV
  - Training during purchase
  - In-person training

**Older Drivers**
- Want to learn:
  - Hands-on Demo
  - Training during purchase
  - Test drive training
  - Training at popular locations
- Do not want to learn:
  - Classroom setting
  - DMV
  - Online videos
  - In-person explanation
Research Questions

• What is the optimal method to train drivers on the use of automated vehicle technologies?
  • Do drivers of different ages require different training methods?

• How can we detect behavioral and physiological measures that indicate successful training?
VTTI Test Track Study – Research Objectives

• To understand if presenting ADAS information in a multimedia format would improve driver understanding/comprehension as well as driving performance.
  • Multimedia vs. digital owners manual

Dependent Measures:
• Operator knowledge of automated vehicle systems
• Performance (skill and behavior) when using the automated vehicle system
• Attitudes toward automated vehicle systems
• Attitudes toward the training program
## Study Overview

<table>
<thead>
<tr>
<th></th>
<th>Conventional Training</th>
<th>Multimedia Training</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Younger Participants (18 – 25)</strong></td>
<td>10 (M = 21.4, SD = 1.58)</td>
<td>10 (M = 21.1, SD = 1.37)</td>
<td>20 (M = 21.25, SD = 1.45)</td>
</tr>
<tr>
<td><strong>Older Participants (55 – 75)</strong></td>
<td>10 (M = 59.7, SD = 5.64)</td>
<td>10 (M = 66.2, SD = 7.63)</td>
<td>20 (M = 62.95, SD = 7.33)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20 (M = 40.55, SD = 20.06)</td>
<td>20 (M = 43.65, SD = 23.74)</td>
<td>40 (M = 42.1, SD = 21.75)</td>
</tr>
</tbody>
</table>

- **Training Protocols:**
  - Participant completed one of two training protocols while sitting in the parked research vehicle.
Study Divisions

Training module: each participant will receive one of two training protocols

Pre-Training
- Knowledge
- Attitude – AVS

Post-Training
- Knowledge
- Attitude – Training
- Attitude – AVS

Test Track Drive
- Performance
- Behavior

Post-Drive
- Knowledge
- Attitude – Training
- Attitude – AVS
Metrics

• Knowledge
• Number of inadvertent system deactivations (Skill)
• Hands on Wheel Alert (Behavior)
• Mean Off Road Glance Duration (Behavior)
• Trust (Attitude toward AVS)
• Attitudes toward Training
Methods - Training
Research Environment

- Virginia Smart Road Highway
  - A 1 mile section of the Smart Road was used
  - 2 × 0.3 mile secondary task section
  - 0.3 mile transition area, no secondary tasks to be completed
- Confederate vehicle on the test track that was either lead or following vehicle
Smart Road Study

• AVS State
  • Systems On: Lateral and longitudinal control of the vehicle is managed by the automated systems
  • Systems Off: Lateral and longitudinal control of the vehicle is managed by the human operator

• Secondary Task
  • None: No secondary task was performed
  • Task: Secondary tasks of varying complexity were performed continuously on specific segments of road
Results - Operator Knowledge

• Where it works:
  • Older participants were more likely to identify the roadway environments where it would be appropriate to use ACC and Lane Keeping than younger participants.

• Situations where it may not work as expected:
  • Most participants (both age groups) were unable to correctly identify all situations where systems may not work as expected.
Results - Operator Knowledge

• Sensors used:
  • ACC: No main effects were found to contribute. Many participants responded correctly to this question.
  
  • LKA: Participants who completed multimedia training were approximately 3 times as likely to respond correctly than those who completed conventional training (OR: 2.97, CI: 1.07, 8.23).
Results – Deactivations & Alerts

• Number of System Deactivations
  • Younger operators had a lower incident rate of system deactivations than operators in the mature demographic (IR: 0.24, CI: 0.10, 0.55).

• Number of Hands on Wheel Alerts & Severity
  • 15 participants received 41 hands on wheel alerts
    • 53.7% of alerts were Visual + Audio
Results – Mean Glance off Road

Mean off Road Glance Duration (sec.)

- System Off
- System On

Categories:
- NONE
- TASK
- MATURE
- YOUNGER
Results – MGOR Over Time

Mean off Road Glance Duration (sec.)

- **EARLY**
  - OFF: 0.5
  - ON: 0.8

- **LATE**
  - OFF: 0.7
  - ON: 0.6

Legend:
- **OFF**
- **ON**
Results – Attitudes toward AVS

• I would rely on vehicle automation to function properly while I am doing something else.
  • Younger participants tended to have a higher numeric response to the reliance on automation to function properly while doing something else (M = 4.1, SD = 1.8). Participants in the mature demographic were less inclined to rely on the vehicle automation to function properly while performing other tasks (M = 3.15, SD = 1.4).

• Vehicle automation gives false alerts.
  • Participants who received multimedia training were more inclined to believe that vehicle automation provides false alerts compared to participants who received conventional training.

• Vehicle automation is dependable
  • Participants were more inclined to agree with the statement “Vehicle automation is dependable” after driving the vehicle.
I am familiar with vehicle automation.
I trust vehicle automation
Results – Attitudes toward Training

• Age Group
  • Most older participants reported the training and driving experience equally helpful (N=11).
  • Many younger participants reported experience with driving as most helpful (N=14).

• Training
  • Recipients of the conventional protocol most frequently reported experience with driving as most helpful (N=12). There was an even split for those with multimedia training.
Conclusions

• We did not find a significant effect of training type; however, same material was presented in different formats.

• Mean glance off road were longer with systems active and indicated that this may increase over time.

• Driver’s understanding of ADAS will continue to change over time through driving experience.
  • Thus there should be ways to enhance learning through experience with feedback
  • Current monitoring protocols may not be sufficient feedback (i.e. hands on wheel)

• Trust and confidence increase post-drive.

• Training materials need to be developed that address the needs of adult learners.
Overall Conclusions

• We will need to develop a variety of training options
  • A one size fits all approach will probably not work

• Will require the buy in from multiple stakeholders
  • Responsibility for training can’t be dropped on one agency/stakeholder’s lap

• May need to provide incentive/motivation for drivers to obtain training
Future Work

• Examine driver interaction with the vehicle automation over time (short term and long term) in order to:
  • Determine driver proficiency as a result of unstructured self-guided learning
  • Identify safety critical incidents/behaviors that could be corrected through training

• Develop novel *in-vehicle* training materials and assess effectiveness
  • In-vehicle monitoring and feedback has been shown to improve driving performance in teens...could apply this to in-vehicle training mode.
  • Another option to train drivers on system failures vs specific scenarios
Questions??
Next Steps, Funding Needs, Timelines

• Conduct an on-road study assessing novel in-vehicle training protocols.
  • Partner with Safe-D UTC (50/50 split)

• Total project $400,000 ($200K UTC/$200K Auto Alliance)

• Timeline: 18 months with preliminary results at 12 months