Trust in Automated Vehicles

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Adoption and use of technical systems
- users' needs and requirements for technical systems
- use and meaning of technical products and systems
- prerequisites for users' adoption of new technologies

Human-machine systems (incl HMI)
- interplay between human and "machine" – from simple products to complex socio-technical systems
- performance, safety

Sustainability and everyday life
- design for sustainable behaviour
- understanding behaviour and change

User experience
- sensing, perceiving and react to products and events
- aesthetics
- product identity and meaning

Mikael Johansson, PhD Student
Drivers'/Users' Understanding of Automated Vehicles

Fredrick Ekman, PhD Student
Drivers'/Users' Trust in Automated Vehicles
Expert Systems

- Professional Training
- High degree of system understanding
- Time for Consideration
- Team work

Automated Vehicles (AVs)

- Novice users
  - Little training
  - Low system understanding

- Adoption/Acceptance
  - Choice to adopt
  - Trust highly important
Implications

- Mistrust
  - Using the system in an unintended way
  - Accidents

- Distrust
  - Not adopting the system
Trust Fundamentals

Trustgiver & Trustee  Incentive  Possibility to Fail (Risk)

(Lee & See, 2004)

Processing Trust

Analogical Process

Analytic Process

Affective Process

(Lee & See, 2004)
In Order to Achieve Trust

Performance  Purpose  Process

(Lee & See, 2004)

Factors Influencing Trust

(Hoff & Bashir, 2016)
Factors Influencing Trust

Automated Vehicle Research

• “Providing user with “how and why” information regarding imminent autonomous action results in the safest driving performance but increases negative feelings in drivers.” (Koo et al., 2015)
• “Users who were provided with the uncertainty information trusted the automated system less than those who did not receive such information.” (Helldin et al., 2013)
• “Trusting smart systems depends on those systems sharing the user’s goals” (Verberne et al., 2012)
• “Participants trusted that the vehicle would perform more competently as it acquired more anthropomorphic features.” (Waytz et al., 2014) However, another study showed that anthropomorphic features had a low effect on trust. “Instead, the way in which the car manoeuvred and handled obstacles was a major carrier of trust.” (Aremyr et al., 2018)
Automated Vehicle Research

- Graphical User Interfaces

- Not much focus on implicit cues
  - AV driving behavior
    - Acceleration/Deceleration
    - Lane positioning

Experimental Study

- Does a Automated vehicle’s driving behavior affect trust?

- Comparing two simulated AV driving behaviors at AstaZero with a Wizard-of-Oz-car
  - No graphical user interface
  - No secondary task
### Defensive vs. Aggressive Driving Behavior

<table>
<thead>
<tr>
<th></th>
<th>Defensive</th>
<th>Aggressive</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Starting &amp; stopping</strong></td>
<td>Keep the vehicle rolling (avoid standstill)</td>
<td>Start &amp; stop (come to full stop)</td>
</tr>
<tr>
<td><strong>behaviour</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Acc./Retardation</strong></td>
<td>Avoid heavy acc/deacc.</td>
<td>Heavy acc/deacc.</td>
</tr>
<tr>
<td><strong>pattern</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Lane positioning</strong></td>
<td>Early indicate right or left turn (through positioning in lane)</td>
<td>Indicate late right or left turn (through positioning in lane)</td>
</tr>
<tr>
<td><strong>Distance to object</strong></td>
<td>Keep longer distance (lateral &amp; longitudinal) to other objects</td>
<td>Keep shorter distance (lateral &amp; longitudinal) to other objects</td>
</tr>
</tbody>
</table>

### Study procedure

- 18 participants between 20 and 55 years (50/50 male/female)
- Rated trust in predetermined situations
3. Overtaking moving car
4. Left turn into roundabout and left turn in roundabout
5. Pedestrian walking over zebra-crossing
7. Passing cyclist
2. Stop-light intersection
1. Start
8. Meeting other car

Situation 2,3,5,7 is primary situations
Situation 1,4,6,8,9 is secondary situations
Results Questionnaire – Aggressive vs. Defensive

- I understood how the self-driving car operated
- I had full confidence in the competence of the self-driving car
- I thought the self-driving car was safe to ride
- I could trust the self-driving car
- I believe the car did what was best for me

I thought the car’s driving behaviour felt predictable

If my car worked like this, I would let it drive by itself
If my car drove by itself, the experience would be better than driving on my own
Perception of the AV behaviour

- Vehicle capacity (Performance)
  - Planned decisions
    - Clearly showing position in lane
    - No sudden actions
    - Smooth turns (without perceived continuous compensation)
- User's understanding of the AV's upcoming actions (Process)
  - Gentle actions but distinct lane placement before situation
  - Coming to full stop (when giving way for VRU)
- Respect towards VRU (Purpose)
  - Placement (lateral, direction of car, and in time)
  - Speed
  - Coming to full stop (when giving way for VRU)

The perceived intelligence of the automation depended on the situations

- In critical situations, Defensive mode was preferred since it more clearly communicated the intention of the car
  - e.g. early slow down for pedestrian
- In none critical situation, Aggresive mode was preferred since it was perceived as more effective
  - e.g. narrow turn in roundabout
Discussion

• To communicate the intention of the car emerged as an important factor
  • The driving behavior communicates the intention – is the car aware of the surroundings?
  • Can the behavior of the car be used intentionally to communicate the intention of the car?
  • HMI

• How to match the driving behavior to the graphical user interface?
  • How to sync cues from driving behavior with cues graphical in user interface?
  • Difference between a “Defensive” interface and a “Aggressive” interface?

Conclusions

• The participants related the driving behavior to car having intelligence/agency

• The driving behavior affected the trust of the participants

• People experienced the automated car as a whole

• The vehicle dynamics and driving pattern need to be seen an essential part of user interface of the car to create trust

• The whole autonomous car is the user interface to the driver/passenger
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