Interactions of autonomous vehicles and cyclists:

Results from real-world and simulator trials

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Objectives

• Develop AV technologies
• Consider public acceptance
• Consider insurance and legal implications

Trials

1. Planned hand-back of control to a driver
2. Exploring interactions with other motor vehicles
3. Investigating trust in AVs during interactions with other road users, such as cyclists and pedestrians.
<table>
<thead>
<tr>
<th>Event</th>
<th>Depiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing zebra</td>
<td><img src="image1" alt="Crossing zebra" /></td>
</tr>
<tr>
<td>Crossing zebra with pedestrian</td>
<td><img src="image2" alt="Crossing zebra with pedestrian" /></td>
</tr>
<tr>
<td>Overtaking a parked car</td>
<td><img src="image3" alt="Overtaking a parked car" /></td>
</tr>
<tr>
<td>Overtaking parked car with oncoming cyclist</td>
<td><img src="image4" alt="Overtaking parked car with oncoming cyclist" /></td>
</tr>
<tr>
<td>Turning right into side road</td>
<td><img src="image5" alt="Turning right into side road" /></td>
</tr>
<tr>
<td>Turning right into side road with pedestrian</td>
<td><img src="image6" alt="Turning right into side road with pedestrian" /></td>
</tr>
<tr>
<td>Turning right into side road with cyclist</td>
<td><img src="image7" alt="Turning right into side road with cyclist" /></td>
</tr>
</tbody>
</table>
Participants and overall scores

134 people

48 female
86 male

Ages 18 to 79
(mean 50)

49 in driver role
45 in cyclist role and
40 in pedestrian role

132 have passed a driving test
10 months to 49 years driving experience
<table>
<thead>
<tr>
<th>Location</th>
<th>Encounter</th>
<th>All respondents</th>
<th>Cyclists</th>
<th>Drivers</th>
<th>Pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean n=95</td>
<td>Mean n=33</td>
<td>Mean n=35</td>
<td>Mean n=27</td>
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<tr>
<td>Zebra crossing</td>
<td>None</td>
<td>8.4</td>
<td>1.35</td>
<td>8.2</td>
<td>1.12</td>
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<td></td>
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<td>1.52</td>
<td>8.2</td>
<td>1.35</td>
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<tr>
<td>Parked car</td>
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<td>7.7</td>
<td>1.52</td>
<td>7.5</td>
<td>1.52</td>
</tr>
<tr>
<td></td>
<td>Cyclist</td>
<td>8.2</td>
<td>1.40</td>
<td>8.1</td>
<td>1.47</td>
</tr>
<tr>
<td>Junction</td>
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<td>1.31</td>
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<td>1.18</td>
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<tr>
<td></td>
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<td>7.7</td>
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<td>8.2</td>
<td>1.32</td>
<td>8.2</td>
<td>1.17</td>
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<tr>
<td>Simulator</td>
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<td>n=110</td>
<td>n=37</td>
<td>n=41</td>
<td>n=32</td>
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<tr>
<td>Zebra crossing</td>
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<td>7.3</td>
<td>1.84</td>
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</tr>
<tr>
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<td>1.51</td>
<td>7.6</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>Cyclist</td>
<td>7.8</td>
<td>1.54</td>
<td>7.7</td>
<td>1.36</td>
</tr>
<tr>
<td>Junction</td>
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<td>7.8</td>
<td>1.64</td>
<td>7.5</td>
<td>1.47</td>
</tr>
<tr>
<td></td>
<td>Pedestrian</td>
<td>7.9</td>
<td>1.47</td>
<td>7.5</td>
<td>1.52</td>
</tr>
<tr>
<td></td>
<td>Cyclist</td>
<td>8.1</td>
<td>1.38</td>
<td>7.8</td>
<td>1.34</td>
</tr>
</tbody>
</table>

The red 7.3: first event, and responses suggest participants slightly taken aback
1 Effect of pedestrian/cyclist presence: AV

Only significant differences in scores in the AV:

Pedestrian presence decreased the trust score at the zebra crossing (8.4 to 8.1)
- *Does the presence of a pedestrian acts as a reminder of the risk involved?*

Cyclist’s presence increased the trust score when overtaking a parked car (7.7 to 8.2)
- *Did participants wonder at the AV’s intentions with an on-coming vehicle when it is absent?*
1 Effect of pedestrian/cyclist presence: Simulator

Only significant difference in scores in the Simulator

- **Does the presence of other traffic give confidence that the AV is behaving properly?**
- **Was the AV too cautious?**

No other road user (score 7.8)

Cyclist (score 8.1)

Pedestrian (score 7.9)

- Significantly different $p = 0.001$
- Not significantly different ($p > 0.999$)
- Significantly different $p = 0.007$
2 Effect of respondent role

No statistically significant differences in trust ratings given by cyclist, driver and pedestrian participants
3 Effect of platform

Only significant differences in trust scores:

**Junction**: The significance of only the events (not the platform or the interactions) suggests the platform has no effect.

**Parked car**: With and without on-coming cyclist are not the same for each platform (the interaction was significant), i.e. the platform is moderating the response.
4 Effect of driver vs autonomy

Only significant differences in trust scores:

**Parked car**: trust higher when manually driven
- *Is there still progress to be made with very complex manoeuvres?*

**Right turn with cyclists**: trust highest anyway, but higher when manually driven (8.5 versus 8.2).
- *Does this reflect the AV was apparently too cautious?*
5 Correlation with psychometric tests

• Psychometric tests included: driving experience questionnaire; Faith and Trust Stance in General Technology; Trust in Automation; Impulsivity; Self-control; Risk taking; Distractibility; Personality; Sleep; Mood; Cognitive workload.

• There were no associations with age, years since driving test or annual mileage

• Low to medium strength positive association between the trust scores for all events, bar overtaking a parked car with oncoming cyclist in the AV.
Summary and implications

1 Effect of presence of pedestrians and cyclists
   • Trust ratings were high, but no overarching pattern in the scores that were statistically significantly different
   • Trust higher with a cyclist present: is the vehicle apparently too cautious, or are people re-assured?

2 Effect of participant role (pedestrian/cyclist/driver)
   • Neither role nor their viewpoint impact trust: *no need to differentiate messaging for different audiences*

3 Platform
   • Research in simulation prior to real world appears to be useful

4 Effect of manual driving versus autonomy
   • Higher trust in manually driving for four out of the seven scenarios (but order effect?)

5 Personality type
   • No correlations with age or driving experience, but correlations between trust in autonomy and reported trust scores: *do we need to guard against being too trusting?*