Naturalistic Passenger Behavior: Non-Driving Postures and Activities in Front Seats

Updated 2020-02

Matt Reed, Sheila Ebert, Monica Jones, Jason J. Hallman*
What Will Passengers in Automated Vehicles Do?

Fun images from the web
What Will Passengers in Automated Vehicles Do?

Since general-purpose automated road vehicles do not yet exist, what’s the best way to predict what future passengers will do?

Study passenger behavior in current vehicles
Methods

- Instrument 75 privately owned vehicles with interior cameras
- Driven as usual for two weeks
- Manual coding of video to identify front-seat passenger behaviors
- Video-based method for estimating seat position and seat back angle
Seat Position and Back Angle Calibration

Record seat position on arrival (mm forward of full rear)

Record seat back and seat cushion angles

Tool developed in Huang and Reed (2006) to estimate SAE J826 manikin measures
Seat Position and Back Angle Calibration

Reflective markers placed on seats

Seat moved through 5 increments of seat position x seat back angle

Calibration function was calculated to estimate seat position and seat back angle from location of markers in video frame
Coding Videos

- Initial viewing of videos to identify trips with passengers
- Logging occupancy, belt use
- Sample video frames approximately one per five minutes
High-Level Summary

In 75 vehicles:

2733 trips with front-seat passengers
51128 total front-seat passenger minutes
306 unique front-seat passengers
13638 video frames coded
5 frames per trip on average
3.7 minutes of travel time represented by each frame

Passenger is female in 72% of frames
(GES with induced exposure: 62%)
Trip Duration

Cumulative Fraction

Trip Duration (min)

*2017 National Household Travel Survey (self-report)
Seat Belt

Overall 97% belt use

Shoulder Belt
- 71.5% MidClavicle
- 21.5% LatClavicle
- 2.7% None
- 2.7% OnNeck
- 0.8% ForwardofBody
- 0.7% UnderArm

Lap Belt
- 85.0% OnLap
- 12.4% OnBelly
- 2.1% None
- 0.3% Can't Tell
- 0.3% Missing
## Activities

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Percent</th>
<th>F</th>
<th>M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talking</td>
<td>46.0%</td>
<td>45.9%</td>
<td>45.6%</td>
</tr>
<tr>
<td>Phone</td>
<td>26.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nothing</td>
<td>25.9%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>5.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food</td>
<td>3.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>2.2%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drink</td>
<td>1.6%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(More than one behavior could be tabulated per frame)

(Only one behavior per frame)
Activities

Activities in 10-minute bins

Fraction of Time

Time in Trip (min)

Talking
Phone
Resting
Eating/Drinking

All frames > 100 mins
Minimal data
### Postures – Deviations from Nominal

<table>
<thead>
<tr>
<th>Head Roll %</th>
<th>Value</th>
<th>Head Yaw %</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>84.9%</td>
<td>Neutral</td>
<td>65.4%</td>
<td>Neutral</td>
</tr>
<tr>
<td>10.1%</td>
<td>Tilt Right</td>
<td>19.1%</td>
<td>Rotated Right</td>
</tr>
<tr>
<td>3.7%</td>
<td>Tilt Left</td>
<td>14.1%</td>
<td>Rotated Left</td>
</tr>
<tr>
<td>1.1%</td>
<td>Missing</td>
<td>1.1%</td>
<td>Missing</td>
</tr>
<tr>
<td>0.3%</td>
<td>Can't Tell</td>
<td>0.3%</td>
<td>Can't Tell</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Head Pitch</th>
<th>Value</th>
<th>Face Direction %</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>67.1%</td>
<td>Neutral</td>
<td>55.0%</td>
<td>Windshield</td>
</tr>
<tr>
<td>28.6%</td>
<td>Down</td>
<td>22.5%</td>
<td>Lap</td>
</tr>
<tr>
<td>3.0%</td>
<td>Back</td>
<td>13.2%</td>
<td>Pas Window</td>
</tr>
<tr>
<td>1.1%</td>
<td>Missing</td>
<td>7.5%</td>
<td>Driver</td>
</tr>
<tr>
<td>0.2%</td>
<td>Can't Tell</td>
<td>1.2%</td>
<td>Missing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5%</td>
<td>Can't Tell</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2%</td>
<td>Behind</td>
</tr>
</tbody>
</table>
Postures – Deviations from Nominal

**Torso Roll**
- 84.6% Neutral
- 7.5% Tilt Left
- 6.7% Tilt Right
- 1.1% Missing
- 0.1% Can't Tell

**Torso Pitch**
- 85.6% Neutral
- 9.6% Forward
- 3.6% Backward
- 1.1% Missing

**Torso Yaw**
- 88.5% Neutral
- 5.5% Rotated Right
- 4.8% Rotated Left
- 1.2% Missing
- 0.1% Can't Tell
Non-Neutral Lower Extremity Postures

Left
- 48.5% None
- 37.9% Lifted
- 6.6% Can’t Tell
- 3.4% CrossedUnder
- 2.3% CrossedOver

Right
- 46.2% None
- 39.7% Lifted
- 7.0% Can’t Tell
- 3.8% CrossedOver
- 2.4% CrossedUnder
Non-Neutral Lower Extremity Postures

**Left Leg**
- **Neutral**
- **Lifted**
- **Crossed Under**
- **Crossed Over or Under**

**Right Leg**
- **Neutral**
- **Lifted**
- **Crossed Under**
- **Crossed Over or Under**

Fraction of Time

Time in Trip (min)
No seat position or seat-back-angle change in 40 of 75 (53%) vehicles
16 cases of seat position change

Seat was ~full rear 23% of time
Seat was rearward of mid track 81% of time
Mean seat back angle was 25.4 (6.4) deg

The seat back angle was greater than 30 degrees in approximately 15% of frames and greater than 35 deg in only 84 frames (0.7%).
Summary and Implications

- Visibly poor belt fit is common (>10%)
- Non-nominal passenger postures are common, particularly head rotated or tilted downward (10-50%)
- Passengers sit rearward: 23% full rear, 81% aft of mid track
- Highly reclined postures (>35 deg) are rare

Are restraint systems sufficiently robust to deviations from nominal test postures and belt fit?

Work to improve protection for current passengers will benefit future automated vehicle passengers
Acknowledgement
Contacts

Matt Reed
mreed@umich.edu