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

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* Toyota
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

Grayscale camera with IR illuminators
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
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

Through 57 vehicles:

- 2347 trips with passengers
- 35567 minutes of front-seat passenger trips
- 237 unique front-seat passengers
- 8.5 trips per passenger on average
- 9450 video frames coded
- 4.7 frames per trip on average
- 3.8 minutes of travel time represented by each frame

Passenger is female in 71% of frames (GES with induced exposure: 62%)
Trip Duration

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

Overall 97% belt use

Shoulder Belt
- 73.5% MidClavicle
- 19.1% LatClavicle
- 2.9% None
- 2.8% On Neck
- 1.0% Under Arm
- 0.6% Forward of Body

Lap Belt
- 88.8% OnLap
- 8.9% OnBelly
- 2.0% None
- 0.3% Can't Tell
- 0.0% Missing
## Activities

<table>
<thead>
<tr>
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<th>F</th>
<th>M</th>
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<tbody>
<tr>
<td>Talking</td>
<td>44.3%</td>
<td>43.7%</td>
</tr>
<tr>
<td>Nothing</td>
<td>26.1%</td>
<td>32.8%</td>
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<tr>
<td>Phone</td>
<td>20.4%</td>
<td>15.1%</td>
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<tr>
<td>Other</td>
<td>4.6%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Resting</td>
<td>2.1%</td>
<td>2.7%</td>
</tr>
<tr>
<td>Food</td>
<td>1.6%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Drink</td>
<td>0.9%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Missing</td>
<td>0.1%</td>
<td>0.4%</td>
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<tr>
<td></td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
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(Only one behavior tabulated)
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>
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</thead>
<tbody>
<tr>
<td>85.1%</td>
<td>Neutral</td>
<td>64.5%</td>
<td>Neutral</td>
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<tr>
<td>10.6%</td>
<td>Tilt Right</td>
<td>19.9%</td>
<td>Rotated Right</td>
</tr>
<tr>
<td>3.9%</td>
<td>Tilt Left</td>
<td>15.2%</td>
<td>Rotated Left</td>
</tr>
<tr>
<td>0.4%</td>
<td>Can't Tell</td>
<td>0.4%</td>
<td>Can't Tell</td>
</tr>
<tr>
<td>0.0%</td>
<td>Missing</td>
<td>0.0%</td>
<td>Missing</td>
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<table>
<thead>
<tr>
<th>Head Pitch</th>
<th>Face Direction</th>
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<tbody>
<tr>
<td>67.6%</td>
<td>Windshield</td>
</tr>
<tr>
<td>29.1%</td>
<td>54.5%</td>
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<tr>
<td>3.0%</td>
<td>22.8%</td>
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<tr>
<td>0.3%</td>
<td>13.9%</td>
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<tr>
<td>0.0%</td>
<td>7.8%</td>
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[UMTRI Logo]
Postures – Deviations from Nominal

Torso Roll

85.0% Neutral
8.0% Tilt Left
6.9% Tilt Right
0.1% Can't Tell
0.0% Missing

Torso Pitch

86.5% Neutral
9.9% Forward
3.5% Backward
0.1% Can't Tell

Torso Yaw

89.6% Neutral
5.8% Rotated Right
4.4% Rotated Left
0.1% Can't Tell
0.0% Missing
Non-Neutral Lower Extremity Postures

Left
- 47.0% Neutral
- 38.9% Lifted
- 7.0% Can’t Tell
- 4.3% Crossed Under
- 2.7% Crossed Over

Right
- 43.7% Neutral
- 41.9% Lifted
- 7.1% Can’t Tell
- 4.7% Crossed Over
- 2.9% Crossed Under
Non-Neutral Lower Extremity Postures
No seat position or seat-back-angle change in 30 of 57 (52%) vehicles
9 cases of seat position change

Seat was ~full rear 25% of time
Seat was rearward of mid track 91% of time
Median seat back angle was 25 deg

The seat back angle was greater than 30 degrees in approximately 10% of frames and greater than 35% in only 7 frames (<0.1%).
Summary and Implications

• Visibly poor belt fit is common (>10%)
• Non-nominal passenger postures are common (10-50%)
• Passengers sit rearward: 25% full rear, 91% 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

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