Prevalence of Non-Nominal Seat Positions and Postures Among Front-Seat Passengers

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Non-Nominal Postures

Most design and optimization of vehicle occupant protection systems uses ATDs and other surrogates in nominal postures.

Recent research has demonstrated dynamic events (e.g., hard braking) can move passengers “out of position”.

How common is “out of position” in normal travel for front-seat passengers?
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

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
- 0.7% UnderArm
# 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>%</td>
<td></td>
<td>%</td>
<td></td>
</tr>
<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>
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</table>

<table>
<thead>
<tr>
<th>Head Pitch</th>
<th>Face Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>67.1%</td>
<td>Windshield</td>
</tr>
<tr>
<td>28.6%</td>
<td>Lap</td>
</tr>
<tr>
<td>3.0%</td>
<td>Pas Window</td>
</tr>
<tr>
<td>1.1%</td>
<td>Driver</td>
</tr>
<tr>
<td>0.2%</td>
<td>Missing</td>
</tr>
<tr>
<td>0.2%</td>
<td>Behind</td>
</tr>
<tr>
<td>0.5%</td>
<td>Can't Tell</td>
</tr>
<tr>
<td>0.5%</td>
<td>Can't Tell</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

<table>
<thead>
<tr>
<th></th>
<th>Left</th>
<th>Right</th>
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</thead>
<tbody>
<tr>
<td>None</td>
<td>48.5%</td>
<td>46.2%</td>
</tr>
<tr>
<td>Lifted</td>
<td>37.9%</td>
<td>39.7%</td>
</tr>
<tr>
<td>Can’t Tell</td>
<td>6.6%</td>
<td>7.0%</td>
</tr>
<tr>
<td>CrossedUnder</td>
<td>3.4%</td>
<td>3.8%</td>
</tr>
<tr>
<td>CrossedOver</td>
<td>2.3%</td>
<td>2.4%</td>
</tr>
</tbody>
</table>

![Example Images of Postures](image1.jpg) ![Example Images of Postures](image2.jpg)
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

- Poor belt fit was observed (>10%)
- Non-nominal passenger postures are common, particularly head rotated or tilted downward (10-50%) or torso rotated (15-20%)
- 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

CSRC
Collaborative Safety Research Center
TOYOTA
Contacts

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<table>
<thead>
<tr>
<th>Behavior</th>
<th>Percent</th>
<th>F</th>
<th>M</th>
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</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)
Activities

Activities in 10-minute bins

Fraction of Time

Time in Trip (min)

Talking
Phone
Resting
Eating/Drinking

All frames > 100 mins
Minimal data