ROAD VEHICLE PASSENGER BEHAVIORS:
A VIDEO STUDY

MATTHEW P. REED, SHEILA M. EBERT,

AND MONICA L.H. JONES

TECHNICAL REPORT

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16. Abstract

Passenger car cabin videos obtained in a previous naturalistic driving study of part-time belt users were coded to characterize front-seat passenger attributes and behaviors. Among the 959 passenger trips, the median trip duration was 10 minutes; the 95th percentile was 52 minutes. Frames from the beginning, middle, and end of trips longer than 5 minutes in duration were extracted for coding, along with a middle frame from trips shorter than five minutes. Front-seat passenger characteristics, postures, and activities were coded in a total 2438 frames. In approximately 72% of frames coded, the passenger was male and 77% of the passengers were estimated to be less than 30 years of age. In 33% of frames, the passenger did not wear the seatbelt. The most common passenger activity was talking (57%); phone interactions were observed in 10% of frames. Passengers were most often looking out the windshield (57%), followed by facing the passenger window (17%), their lap (14%), or the driver (10%). The passenger's torso was rotated away from a neutral posture in more than 25% of frames, including pitched forward (17%), rotated left (6%), or rotated right (4%). The seat back was recorded as reclined beyond normal in 13% of frames, but very reclined in only 1.3% of frames.

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INTRODUCTION

For most vehicle trips in the U.S., the driver is the sole occupant of the vehicle. However, trends in vehicle automation and mobility may result in a greater number of passengers due to ride-sharing and driverless vehicles. Little information is available on passenger behaviors. For example, how often do passengers interact with phones or other electronic devices? How often do they recline the seat beyond a normal posture?

This study quantifies passenger behavior through analysis of a pre-existing video dataset. The videos were recorded from cameras inside the vehicle cabin during an UMTRI study of drivers who were part-time belt users. For the current research, frames from the videos from trips with passengers were extracted for analysis. Using a custom software tool, investigators characterized the passengers and coded behaviors. The methodology was similar to the coding procedures used in Reed et al. (2018) to describe driver behaviors. The resulting data provide a preliminary overview of the activities of a particular population of passengers.

METHODS

Data Source

The videos used for the current analysis were recorded during a naturalistic driving study conducted by UMTRI for the U.S. National Highway Traffic Safety Administration aimed at understanding why some drivers do not always wear seatbelts. The study recruited 24 drivers who admitted to being occasional or intermittent seatbelt wearers. Each participant was provided with one of six instrumented 2007 Honda Accord sedans (Figure 1). The vehicles were equipped to record a wide variety of data including vehicle kinematics, operator controls, radar and video-based measures of nearby vehicles, audio, and video from five different perspectives.

The participants drove the research vehicles for two weeks between September and December 2010 before returning them to UMTRI for data download. Approximately 23,000 miles and 660 hours of driving was recorded. The resulting data include 924 vehicle trips in which at least one passenger was present; these trips nearly always include a front-seat passenger. Figure 2 shows typical frames from the vehicle interior video obtained from a camera located near the inside rear-view mirror.

Figure 1. Exterior (left) and a video camera view of interior (right) of one of the six 2007 Honda Accord research vehicles.

Figure 2. Sample frames from the vehicle interior video.

Two of the three interior cameras gave a good view of the vehicle passengers (Figure 3). The wide-angle lens gave a good view of the interior, but created distortion as illustrated in Figure 4. The locations of the cameras were very similar but not identical for all the test vehicles and drivers (Figure 5).

Figure 3. Two camera views of passenger areas, camera on windshield (left) and on the ceiling (right).
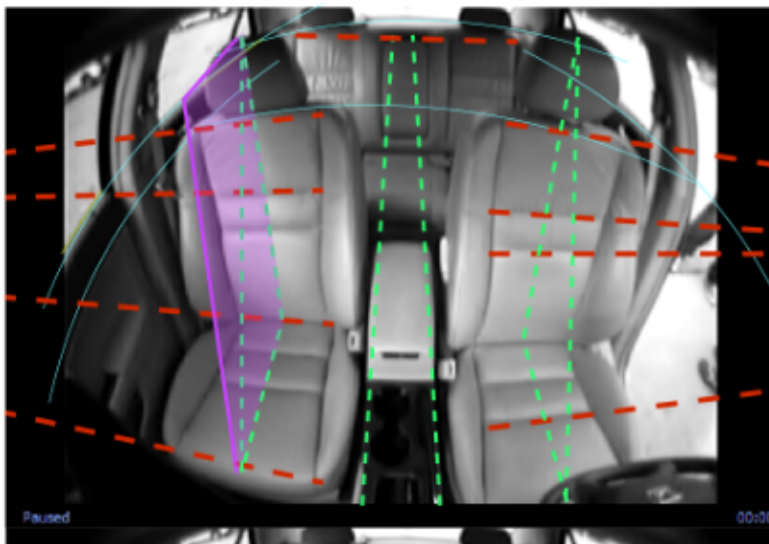

Figure 4. Lines drawn over image from front camera illustrating lens distortion.

Figure 5. Range of camera views in one vehicle across different drivers. The ceiling camera remained relatively fixed, but the windshield camera moved.

Initial Passenger Classification and Belt Fit Coding

The analysis of this database for the original study included passenger counts. However, the position of each passenger, the start and stop of each passenger ride, identification of each passenger as a repeated rider or any description of the passenger was not previously coded.

Passenger Classification

For the current research, investigators viewed all the trips identified as having passengers. Each person who rode as a passenger in a vehicle was given an identification number and a screen shot of them was taken so that they could be tracked through all of their rides. The start and stop times of the rides for each passenger within each trip and their seating positions were recorded. The gender, age, and approximate body dimensions of each passenger were estimated from the videos. Due to the imprecision of this method, age and body dimensions were coded as ordinal categories. Age was coded using the six categories listed in Table 1 and weight estimates used the three categories in Table 2. Sitting shoulder height was estimated by comparison of the videos to images of passengers with known sitting shoulder height seated in the same vehicles during a different study. These heights were evaluated relative to the top of the vehicle seat back and placed into one of 6 height categories (3 male and 3 female). The reference images and category descriptions are in Figure 8.

Table 1
Passenger Age Bins

Group (years)	Description
<2	baby or toddler (should be in CRS with harness)
3-10	school aged (may be in booster seats)
11-16	tweens and young teens
17 to 30	younger adults
30-60	middle aged adults
>60	adults who appear more senior

Figure 6. Screen captures of example passengers from toddler to senior (top- left to bottom-right)

Table 2
Passenger Weight Bins

Weight Group	Description
Lean	thin to proportional weight (~BMI up to 25)
Heavy	bigger build, not lean but not highly obese
Obese	obviously obese, protruding lower abdomen (~BMI >35)

Figure 7. Examples of people coded as lean, heavy, and obese (left to right)

Coding group:	Female-Short	Female-Medium	Female-Tall
Sitting height:	507 mm	Shoulder height: 557 mm	Shoulder height: 607 mm
Shoulder rel. top of seat:	*Very below* (4-6 inches)	*Well below* (2-3 inches)	*Just below* (an inch or so)
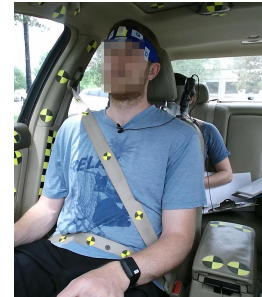
Coding group:	Male-Short	Male-Medium	Male-Tall
Sitting height:	Shoulder height: 553 mm	Shoulder height: 605 mm	Shoulder height: 638 mm
Shoulder rel. top of seat:	*Well below* (2-3 inches)	*Just below* (an inch or so)	At or above (0 or above)

Figure 8. Front seat passenger sitting height category criteria
(images from another study in the same vehicle model)

Belt Fit

Shoulder and lap belt fit were coded using the criteria shown in Figures 9 and 10. The investigators coded the belt fit for each passenger for each trip.
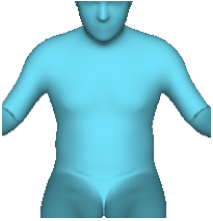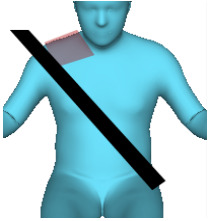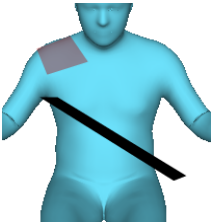

None Not wearing any belt or shoulder belt behind back	**Middle of Clavicle** (good fit)	**Lateral of Clavicle** (poor fit)
Under Arm under outboard arm	**On Neck** laying across neck	**Forward of Body** belt forward of clavicle (not touching)

Figure 9. Shoulder belt fit coding categories
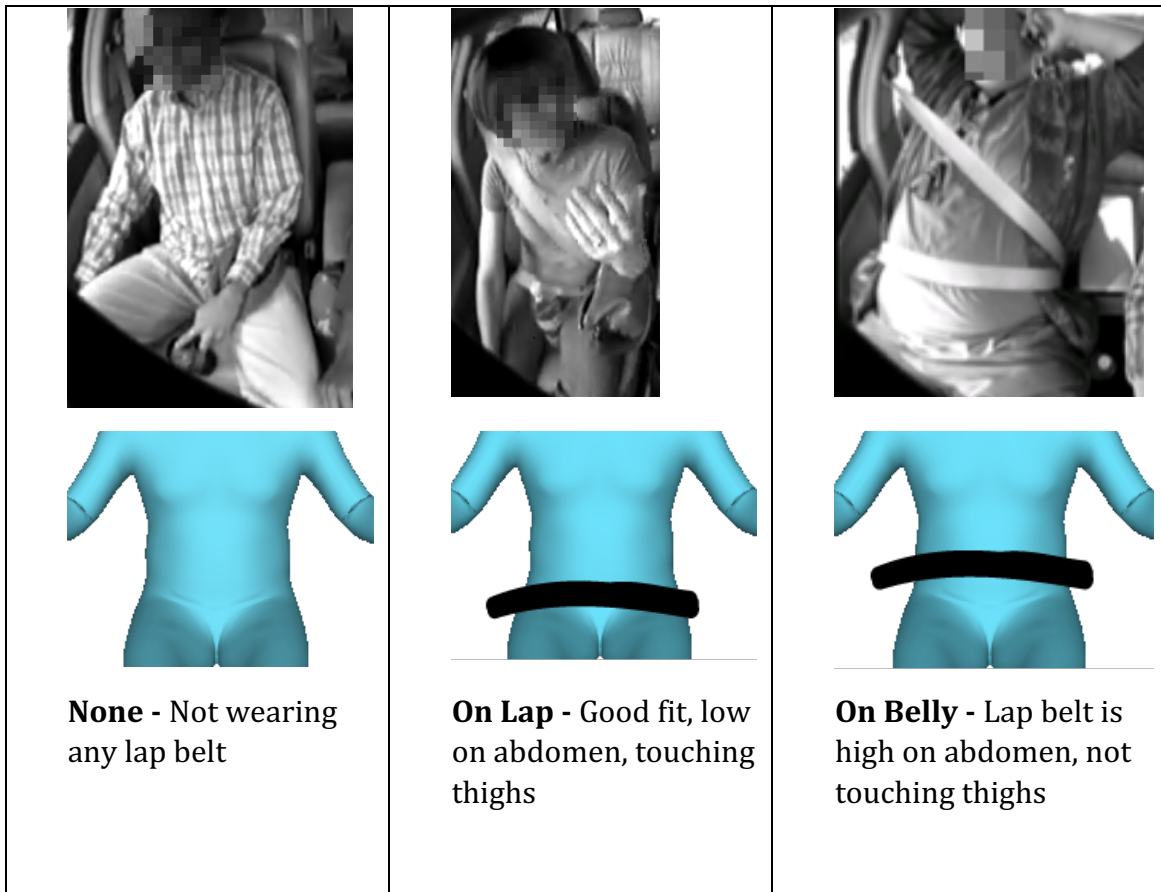
Figure 10. Lap belt fit coding categories

None - Not wearing any lap belt

On Lap - Good fit, low on abdomen, touching thighs

On Belly - Lap belt is high on abdomen, not touching thighs

Video Coding Tool

Figure 11 shows the main input dialog of the software coding tool developed for this study. All investigators were given written instructions similar to the descriptions in this report. An in-person training session included practice coding frames with the trainer as well as independently.

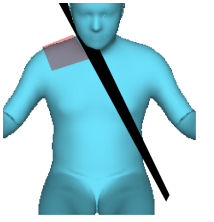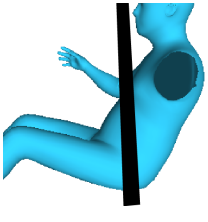The coding tool was divided into two major sections. The top section shown in Figure 11 codes the front seat passenger's physical characteristics and clothing level. The three coding levels are shirt (or less), sweater/jacket (a lighter extra layer) or coat (heavy extra layer or two bulking lighter layers that equal a coat). There was also a multiple checkbox area for general behavioral interactions during the frame and in the minute after the frame. This included resting eyes (eyes closed for the duration), talking with people in the vehicle, using the phone, eating, drinking, or just riding (i.e. just "passenging"/ "nothing")

The larger second section is used for coding front seat passenger body part positions, postures and interactions with the vehicle, other passengers, and items in the passenger's

occupant space. A text box was used for additional coding of postures and behaviors not covered by the options on the form.

Figure 11. Main page of video coding tool

Figure 12. Section of coding tool for passenger physical characteristics and behavioral interactions

Upper Limb Position and Interactions

Examples of the coding sections in the tool for the upper limbs are shown in Figure 13, and the options are listed in Tables 3-5. Figure 14 shows how the regions of the arm were defined. Figure 15 shows screen captures of upper limb orientations.

Figure 13. Section of coding tool for upper limb position and interactions

Table 3
Elbow, Forearm, and Hand Vehicle Contact Coding Options

Interface	Option	Definition
Check boxes (select all that apply)	Armrest	Any area on top or alongside the armrest
	Window/Beltline	Anywhere around the margin of the window on the trim
	Lower Extremity	Touching the lap, thigh, or calf
	Torso	Any part of the torso above the lap
	Nothing	Touching nothing, (out in space)
	Center Stack (for hand only)	The center area of the instrument panel including the area where the radio and climate controls are located
	Other	Some other part of the vehicle (excluding the passenger seat) not listed. *A text entry is required if checked.*
	Can't Tell	Not possible to see or infer

Table 4
Hand Height Options Coding Options

Interface	Option	Definition
Check boxes (select all that apply)	On/slightly Above Lap	On or slightly above the lap area
	Chest to Neck	Above the lap, somewhere in the chest area, but below the neck
	Neck /Head	At the height of the neck or head
	Other	At some other height not listed. *A text entry is required if checked.*

Table 5
Hand Interaction Coding Options

Interface	Option	Definition
Check boxes (select all that apply)	Phone	Phone in the hand (does not need to be using it)
	Food	Includes all food stuffs
	Drink	Any drink
	Center Stack	Doing something with the center stack, not just resting upon it
	Other	Interacting with something in the vehicle (the vehicle itself, an object, or person). *A text entry is required if checked.*
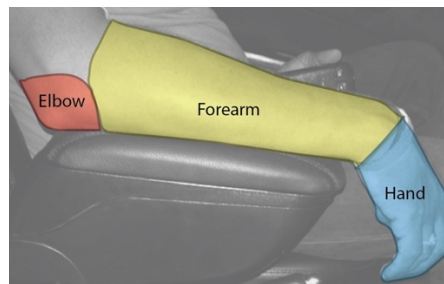
Figure 14. Arm regions

Figure 15. Screen shots of examples of arm locations and interactions

Lower Limb Position and Interactions

The coding sections of the tool for the thighs are shown in Figure 16, and the options are listed in Tables 6 and 7. The instructions indicate that this is the orientation of just the thigh. The lower leg and foot might have a different orientation, but they are not coded in this section. Figure 17 shows screen captures of some thigh orientations.
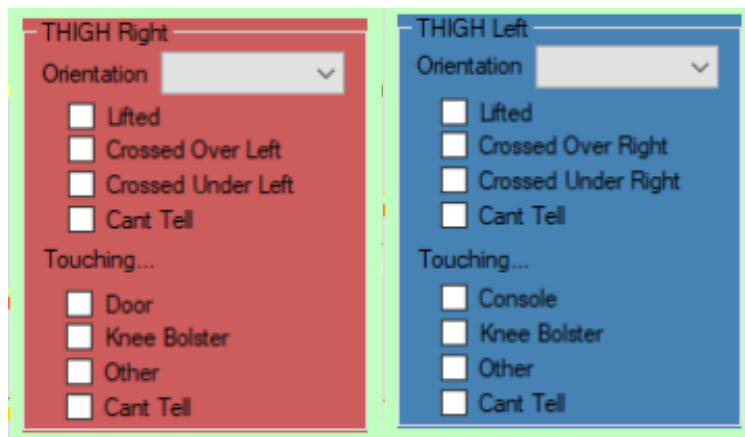
Figure 16. Section of coding tool for coding thigh position

Table 6
Right Thigh Orientation Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Straight	Femur in line with hip
	Lateral	Leg splayed outward
	Medial	Leaning inward a lot, crossing torso centerline
	Can't Tell	Not possible to see or infer
Check boxes (select all that apply)	Lifted	Not all of the thigh touching the seat due to the feet being rearward (usually can tell due to thigh flesh not being spread out on the seat)
	Crossed Over Left	Right leg over the top of the left leg
	Crossed Under Left	Right leg under of the left leg
	Can't Tell	Not possible to see or infer

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Table 7
Right Thigh Vehicle Contact Coding Options

Interface	Option	Definition
Check boxes (select all that apply)	Console	including any of the area that separates the passenger and driver compartment
	Knee Bolster	The padded area in front of the passenger. If they have their knee or other part of the leg touching above the glovebox use "other"
	Other	Some other part of the vehicle (excluding the passenger seat) not listed here. *A text entry is required if checked.*
	Can't Tell	Not possible to see or infer

Figure 17. Examples of thigh postures

Figure 18. Thighs not lifted (top) and lifted (bottom) off the seat cushion

Head Posture Relative to Torso and Face Orientation

The coding sections of the tool covering head orientation relative to the torso and the direction the passenger's face was oriented are shown in Figure 19, and the options are listed in Tables 8-11. Figure 20 illustrates the orientation directions. Figure 21 shows examples.

Figure 19. Section of coding tool for coding head and face

Table 8
Head Roll (Side-to-Side Tilt) Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Neutral	Not tilted to either side relative to the torso
	Tilt Right	Leaning to the right relative to the torso (neck lateral bend right)
	Tilt Left	Leaning to the left relative to the torso (neck lateral bend left)
	Can't Tell	Not visible (even by scrubbing forward-backward several frames)
	Other	*A text entry is required if checked.*

Table 9
Head Pitch (Nod) Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Neutral	Not forward or back relative to torso
	Forward	Tilted down relative to the torso (neck flexion)
	Back	Tilted backward relative to the torso (neck extension)
	Can't Tell	Not visible (even by scrubbing forward-backward several frames)
	Other	*A text entry is required if checked.*

Table 10
Head Yaw (Rotation) Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Neutral	Aligned with torso
	Rot Right	Rotated to right
	Rot Left	Rotated to left
	Can't Tell	Not visible (even by scrubbing forward-backward several frames)
	Other	*A text entry is required if checked.*

Table 11
Face Direction Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Windshield	Forward in the vehicle, in the direction of the windshield (can be a bit to the left or the right)
	Passenger Window	In the direction of the side passenger window (right side)
	Driver	To the left side of the vehicle, in the general direction of the driver
	Behind	Toward the rear of the vehicle
	Lap	Down toward their lap or the floor
	Can't Tell	Not visible (even by scrubbing forward-backward several frames)
	Other	Face is oriented to a location not listed here (most likely ceiling). *A text entry is required if checked.*
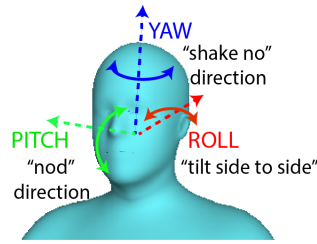
Figure 20. Head orientation directions

Figure 21. Face directions: out side window, lap, windshield, driver, ceiling (left-top to right-bottom)

Torso Position and Orientation Relative to Vehicle Seat

The coding section for torso orientation relative to the vehicle seat is shown in Figure 22 and the options are listed in Tables 12-14. Figure 23 illustrates the orientation directions. Figures 24-26 show examples.
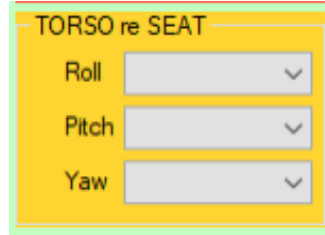
Figure 22. Section of coding for torso posture

Table 12
Torso Roll (Side-to-Side) Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Neutral	Not tilted to either side relative to the seat
	Tilt Right	Leaning to the right relative to the seat
	Tilt Left	Leaning to the left relative to the torso
	Can't Tell	Not visible (even by checking forward-backward several frames)
	Other	*A text entry is required if checked.*

Table 13
Torso Pitch (Leaning Forward or Backward) Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Neutral	Not leaning forward or backward relative to seat back (standard posture relative to seat)
	Forward	Leaning forward from the seat
	Backward	Leaning back in the seat more than would be in standard posture; this would be in conjunction with hips slide forward
	Can't Tell	Not visible (even by checking forward-backward several frames)
	Other	*A text entry is required if checked.*

Table 14
Torso Yaw (Twist) Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Neutral	Not twisted relative to the seat
	Rot Right	Twisted so the chest is more toward the person's right
	Rot Left	Twisted so the chest is more toward the person's left
	Can't Tell	Not visible (even by scrubbing forward-backward several frames)
	Other	*A text entry is required if checked.*
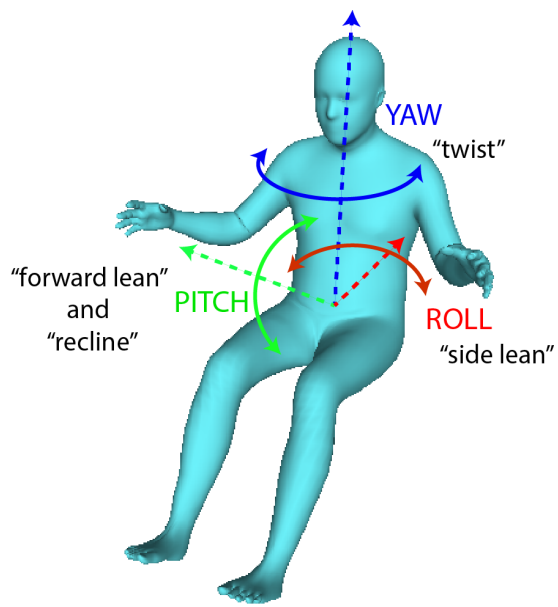
Figure 23. Torso directions

Figure 24. Examples of torso pitched forward (left), neutral (middle), backward (right)
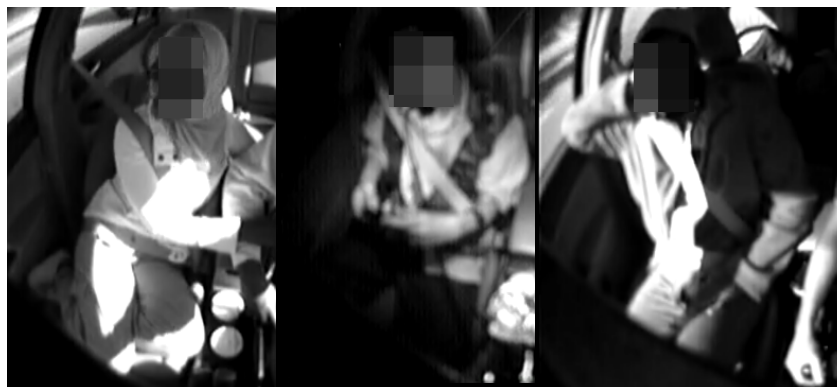
Figure 25. Examples of roll left (left), neutral (middle) and right (right)

Figure 26. Examples of rotation right and left

Pelvis Position and Orientation Relative to Vehicle Seat

The coding section for pelvis position and orientation relative to the vehicle seat is shown in Figure 27, and the options are listed in Tables 15-17. Figure 28 shows examples.
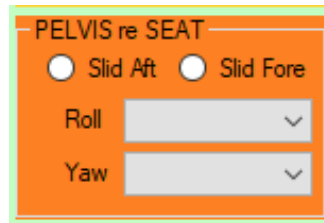
Figure 27. Section of coding for pelvis position and orientation

Table 15
Pelvis Fore-Aft Position Coding Options

Interface	Option	Definition
Radio Buttons (select one)	Slid Aft	*Normal* sitting position
	Slid Fore	Hips slid noticeably forward in the seat

Table 16
Pelvis Roll (Side-to-Side) Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Neutral	Not tilted to either side relative to the seat
	Tilt Right	Tilted to the right; right hip lower in seat than left hip
	Tilt Left	Tilted to the left; left hip lower in seat than right hip
	Can't Tell	Not visible (even by checking forward-backward several frames)
	Other	*A text entry is required if checked.*

Table 17
Pelvis Yaw (Twist) Coding Options

Interface	Option	Definition
Dropdown menu (select one)	Neutral	Not twisted
	Rot Right	Right hip noticeably more rearward in the seat than the left hip
	Rot Left	Left hip noticeably more rearward in the seat than the right hip
	Can't Tell	Not visible (even by checking forward-backward several frames)
	Other	*A text entry is required if checked.*

Figure 28. Examples of pelvis postures in seat.

Contact Between the Midline of the Body and the Vehicle Seat

The coding section for the contact between the head, neck, upper back and lower back with the vehicle seat is shown in Figure 29, and the options of "yes", "no" or "can't tell" (CT) were coded (Tables 18). Figures 30 and 31 show examples.

Figure 29. Section of the coding tool for head and trunk contact with seat surface

Table 18
Body-Seat Surface Contact Regions

Interface	Option	Definition
Radio Buttons for Yes, No or Can't Tell (CT)	Head	Any area of the head
	Neck	Any part of the neck
	Upper Back	Shoulder area (~T4 and up); when passengers are in an alert/neutral posture this part of the back is usually not touching the seat back
	Lower Back	Mid back and inferior; usually in contact when passengers are in a neutral posture, usually not in contact when passenger is slouched in seat and pelvis slid forward

Figure 30. Examples of head touching and not touching

Figure 31. Upper back not touching seat back in a standard posture (left), touching seatback in a slouched posture (center), and touching the seatback in a reclined posture (right)

Vehicle Seat Position

The coding section to describe the position and back recline of the vehicle seat is shown in Figure 32. The seat back recline was coded as upright, semi-reclined, or very reclined. "Upright" was defined as in an upright, normal riding position. "Very reclined" was defined as the seat back reclined to a sleeping position. "Semi-reclined" was defined as anything that fell between "upright" and "very". The seat track position was not used in this phase of

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coding due to the difficulty of visually discerning and classifying differences in the videos as shown in Figure 33.

Figure 32. Section of the coding tool for vehicle seat position and recline angle

Figure 33. Seat track position as viewed from the two camera positions

Additional Coding

To keep the form from being too crowded, events that were less common were entered in the notes area of the coding tool (Figure 34). The wording of these notes was standardized into a four-word pattern that included (1) the occupant position, (2) the who, what or where, (3) direction, side, or type of action, and (4) the item, type of occurrence, duration, or another descriptor (see Appendix C). The codes were organized into a spreadsheet that all coders used. Once a code was developed, it was copied and pasted into the coding tool for any following occurrences. A section of this spreadsheet is shown in Figure 35.

Figure 34. Examples of head touching and not touching

A	B	C	D	E	F
Category	Who/What/Where	Direction/Action/Location	Item/Occurance/HowLong/Descriptor		
WORD 1	WORD 2	WORD 3	WORD 4	As Typed or Copied (EXACTLY)	Additional information
Consol	Top	Center	Purse	Consol Top Center Purse;	Purse placed on consol
Consol	Top	Center	Pet	Consol Top Center Pet;	Pet is on consol
Consol	Top	Center	Object	Consol Top Center Object;	A different object (can't tell what it is) is on the
Consol	Top	Center	Phone	Consol Top Center Phone;	A phone is on the consol
Consol	Top	Center	Cup	Consol Top Center Cup;	cup on console
Cupholder	Inside	Center	Cup	Cupholder Inside Center Cup;	Drink inside cupholder in center consol
Cupholder	Inside	Center	Object	Cupholder Inside Center Object;	An object that isn't a drink is in the cupholder
Cupholder	Inside	Center	Phone	Cupholder Inside Center Phone;	A phone is in the cupholder
Cupholder	Inside	Center	Food	Cupholder Inside Center Food;	Food is in cupholder
Cupholder	Inside	Center	Purse	Cupholder Inside Center Purse;	Purse in cupholder

Figure 35. Examples of head touching and not touching

RESULTS

Passenger Classifications and Belt Fit

Some of the 924 vehicle trips with passengers had multiple legs in which vehicle occupancy varied as people got in and out. If the same passenger was in all legs, the legs were considered one trip for that passenger. In 34 trips, the person in the front seat changed over the course of the trip. With these considered as separate trips, a total of 959 front passenger trips were available for coding, along with 376 rear passenger trips. (Rear passenger presence was noted but detailed coding was not performed for these passengers.)

Frames from the beginning, middle and end of each of 689 passenger rides with a duration of longer than 5 minutes were selected for coding. In addition, a frame from approximately the middle of the 270 rides with a duration of less than five minutes were selected. Approximately 100 additional frames were coded for longer trips, with a total of 2438 frames used for the current analysis.

Figure 36 shows the distribution of front-passenger trip duration. Half of trips are 10 minutes or less; 90% are less than 39 minutes, and 95% are less than 52 minutes.
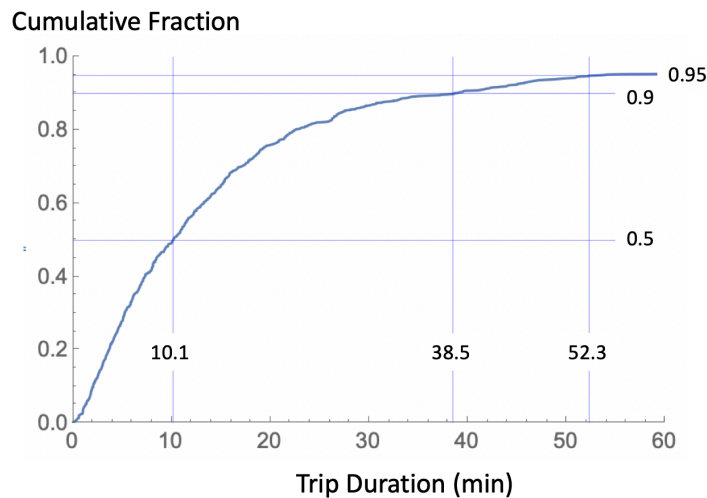
Figure 36. Cumulative distribution of front passenger trip duration.

Table 19 lists the number of trips per passenger position and the total count of different individuals in each position. Table 20 lists the number of trips with passengers for each driver. Table 21 lists the average number of rides for each identified passenger. The number of trips per passenger varied from 1 to 50, and drivers also varied in the number of trips with passengers and the number of passengers. Table 22 shows that 56% of front-passenger trips were taken during daylight conditions, whereas 64% of trips with rear-seat passengers occurred in darkness.

Tables 23-26 list the distributions of various characteristics of the passengers. Most passengers were young men; most of them had a lean body type and "medium" sitting height. A slightly majority of passenger trips were taken during daylight. A third of front-seat passengers and over 80% of rear-seat passengers did not wear the seatbelt (Tables 27-28). When the belt was worn, the belt was most commonly on the lap and clavicle rather than in any of the identified positions associated with poor fit.

Table 19
Number of Trips in Database with Occupants

	Front	Right Rear	Center Rear	Left Rear
Total Trips Taken with Passengers	959	281	67	176
Number of Different People in Passenger Position	187	110	34	75

Table 20
Number of Trips with Passengers Per Driver

Driver	Front	Right Rear	Center Rear	Left Rear
Dri01	11	14	2	7
Dri02	43	20	3	12
Dri03	34	14	6	8
Dri04	45	3	0	1
Dri05	29	3	3	6
Dri06	29	0	0	1
Dri07	19	0	0	0
Dri08	8	17	2	21
Dri09	79	18	4	12
Dri10	23	9	0	4
Dri11	19	18	22	17
Dri12	68	26	8	13
Dri13	87	2	0	2
Dri14	44	0	9	12
Dri15	95	0	0	0
Dri16	1	34	0	0
Dri17	2	15	2	19
Dri18	37	23	0	1
Dri19	56	26	2	16
Dri20	78	25	0	11
Dri21	104	1	0	0
Dri22	2	11	3	7
Dri23	30	2	1	5
Dri24	16	14	2	7
Average	40	15	5	9
SD	31	10	6	6
Min	1	1	1	1
Max	104	34	22	21

Table 21
Rides Per Passenger

	Front	Right Rear	Center Rear	Left Rear
Average	5	2.5	2	2
SD	7	3	1	2
Min	1	1	1	1
Max	50	21	6	3

Table 22
Ambient Light Levels for Trips with Front and Rear Seat Passengers

Light Level	Front (%)	Rear (%)
Daylight	55.5	36
Dark	44.5	64

Table 23
Gender of Passengers by Position

Gender	Front (%)	Right Rear (%)	Center Rear (%)	Left Rear (%)
Male	72	78	73	83
Female	28	22	27	17

Table 24
Age Group by Position

Age Group (yr)	Front (%)	Right Rear (%)	Center Rear (%)	Left Rear (%)
0-2	0	1	0	0
3-10	<1	5	10	2
11-16	<1	0	0	0
17-30	77	72	90	83
30-60	22	20	0	15
> 60	1	2	0	0

Table 25
Passenger Weight Group by Position

Weight Group	Front (%)	Right Rear (%)	Center Rear (%)	Left Rear (%)
Lean	82	71	90	84
Heavy	12	20	10	11
Obese	6	9	0	5

Table 26
Percent Sitting Height by Position

Sitting Height Relative to Seat Group*	Front (%)	Right Rear (%)	Center Rear (%)	Left Rear (%)
Female, short	16	12	12	4
Female, medium	11	8	18	12
Female, tall	1	0	0	0
Male, short	11	11	15	42
Male, medium	47	39	55	17
Male, tall	14	30	0	25

* See Figure 8

Table 27
Shoulder Belt Fit by Position

Shoulder Belt Fit Category	Front (%)	Right Rear (%)	Center Rear (%)	Left Rear (%)
Investigator Can't See	<1	1	2	1
None	33	84	93	82
Under Arm	2	0	0	0
Lateral of Clavicle	15	2	0	1
Forward of Body	<1	0	0	0
On Neck	3	<1	3	1
Mid-Clavicle	47	12	2	15

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Table 28
Lap Belt Fit by Position

Lap Belt Fit Category	Front (%)	Right Rear (%)	Center Rear (%)	Left Rear (%)
Investigator Can't See	1	3	2	7
None	32	84	93	82
On Belly	13	0	2	<1
On Lap	54	13	3	11

Front-Passenger Behavior Distributions

Appendices A, B, and C list the results of tabulations of behavior codes. The frequencies of behaviors by frame are shown. Some selected results are presented here.

Passengers were most often looking out the windshield (57% of frames); looking out the passenger window (17%), at their lap (14%) and at the driver (10%) were also common. Table 29 lists the most common interactions. The front passenger was talking in 57% of frames and interacting with a phone in 10% of frames. The passenger's torso was in a non-neutral posture in hundreds of frames, including pitched forward (17%) and rotated left (6%) or right (4%). The seat back was recorded as reclined beyond normal in 13% of frames; the recline angle was coded as "very" reclined in only 1.3% of frames.

Table 29
Interaction Frequencies (% of video frames)

Percent	Behavior
56.9%	Interaction_Talking
22.9%	Interaction_Nothing
13.4%	Interaction_Other
9.9%	Interaction_Phone
3.1%	Interaction_Food
1.7%	Interaction_Drink
1.1%	Interaction_Resting

DISCUSSION AND NEXT STEPS

This dataset provides a preliminary overview of front-seat passenger behaviors. Passengers took relatively short trips, with a typical (median) trip only 10 minutes long. During the trip, the passengers were typically talking; handheld phone interactions were observed in about 10% of frames. However, the passenger was observed holding the phone up to the ear in only about 0.1% of frames. Reclined postures were uncommon, with "very" reclined postures observed in only about 1% of frames.

The current analysis analyzed only three frames per trip (or one frame for trips shorter than 5 minutes). Due to the typical trip length of 10 minutes, the median time between frames was about 5 minutes, but the amount of time "represented" by each frame is variable. Further analyses are underway to more densely sample the longer trips with the goal of having an average of one sampled frame per five minutes of each passenger trip. We do not expect the results to change substantially, since the current frames are a fairly random sample of the passenger behavior in this dataset. However, with a larger number of frames from longer trips, we will be able to assess whether behaviors on longer trips are different from those on shorter trips.

These data are limited by the sample, which has a larger percentage of young men than in the overall front passenger population. Belt use rates are relatively low, consistent with the expectations of this study, which recruited drivers who were part-time belt users. These limitations highlight the need to gather data from a broader, more representative sample of passengers.

REFERENCES

Reed, M.P. and Ebert, S.M. (2018). Upper-extremity postures and activities in naturalistic driving. SAE Technical Paper 2018-01-0846.

Appendix A
Category Tallies

Gender(DB) | **Count** | **Value**
72.9%	1769	M
27.0%	655	F
0.2%	4	

AgeBin(YR) | **Count** | **Value**
74.3%	1804	17-30
23.9%	581	30-60
0.7%	17	11-16
0.6%	15	greater 60
0.3%	7	3-10
0.2%	4	

Weight(DB) | **Count** | **Value**
81.1%	1968	Lean
12.4%	300	Heavy
6.4%	156	Obese
0.2%	4	

SittingHeight(DB) | **Count** | **Value**
46.5%	1130	M-Med
14.9%	361	F-Short
13.4%	325	M-Tall
13.0%	315	M-Short
10.6%	257	F-Med
0.6%	14	FeM-Tall
0.5%	12	Male, medium
0.2%	6	Male, tall
0.1%	3	Female, short
0.1%	3	
0.1%	2	F-Tall

FP_ShouldBelt(DB) Count Value

39.7%	965	MidClavicle
28.0%	680	None
12.7%	308	LatClavicle
9.9%	241	MidClavical
3.0%	74	LatClavical
2.6%	62	OnNeck
2.1%	51	UnderArm
0.9%	21	NA
0.4%	10	ForwardOfBody
0.3%	7	Latclavicle
0.2%	4	Null
0.1%	3	Midclavicle
0.1%	2	Cant tell

FP_LapBelt(DB) Count Value

56.7%	1376	OnLap
27.6%	671	None
13.6%	330	OnBelly
0.9%	21	NA
0.3%	8	Cant tell
0.2%	6	On Lap
0.2%	6	Can't see
0.2%	4	Null
0.1%	3	On Belly
0.1%	3	

SittingHeight(Frame) Count Value

34.5%	837	M-Med
27.2%	661	M-Short
12.7%	309	F-Short
12.5%	304	F-Med
11.9%	288	M-Tall
1.0%	24	F-Tall
0.2%	5	

HeadRoll		**Count**	**Value**
92.0%	2234	Neutral
5.5%	134	Tilt Right
2.1%	52	Tilt Left
0.2%	5
0.1%	2	Cant Tell
0.0%	1

HeadPitch		**Count**	**Value**
80.1%	1944	Neutral
18.1%	440	Down
1.4%	35	Back
0.2%	5
0.1%	3	Cant Tell
0.0%	1

HeadYaw		**Count**	**Value**
59.1%	1436	Neutral
20.6%	499	Rotated Left
19.9%	484	Rotated Right
0.2%	5
0.1%	2	Cant Tell
0.1%	2

FaceDir		**Count**	**Value**
57.0%	1384	Windshield
17.0%	413	Pas Window
13.7%	333	Lap
9.8%	237	Driver
1.5%	36	Behind
0.5%	13
0.5%	11
0.0%	1	Cant Tell

TorsoRoll | **Count** | **Value**

87.0%	2113	Neutral
8.8%	214	Tilt Right
3.9%	95	Tilt Left
0.2%	6	

TorsoPitch | **Count** | **Value**

81.8%	1985	Neutral
17.3%	419	Forward
0.7%	17	Backward
0.2%	6	
0.0%	1	Down

TorsoYaw | **Count** | **Value**

90.0%	2184	Neutral
6.1%	149	Rotated Left
3.5%	84	Rotated Right
0.2%	6	
0.2%	5	

PelvisPos | **Count** | **Value**

87.4%	2121	Slid Aft
12.2%	296	Slid Fore
0.5%	11	

PelvisRoll | **Count** | **Value**

97.3%	2362	Neutral
1.8%	43	Tilt Left
0.4%	10	
0.4%	9	Tilt Right
0.2%	4	Cant Tell

PelvisYaw | **Count** | **Value**

93.1%	2261	Neutral
3.3%	79	Rotated Left
2.8%	69	Rotated Right
0.5%	11	
0.2%	4	Cant Tell
0.2%	4	

SeatTrack	Count	Value
90.1%	2187	Mid
9.5%	230	
0.4%	10	Fore
0.0%	1	Aft

Recline	Count	Value
86.6%	2103	Upright
11.2%	273	Semi
1.3%	32	Very
0.8%	20	

AnyNotCoded*	Count	Value
90.5%	2198	N
9.1%	220	Y
0.4%	10	

* See Appendix C for rare events.

33.2%   ArmLt_Nothing
30.2%   ArmLt_Torso
23.6%   ArmLt_Armrest
23.2%   ArmLt_LowerExt
 8.6%   ArmLt_Other
 0.3%   ArmLt_CantTell
 0.1%   ArmLt_WindowBeltline

33.5%   ArmRt_Torso
30.2%   ArmRt_Nothing
28.9%   ArmRt_LowerExt
15.4%   ArmRt_Armrest
 4.5%   ArmRt_Other
 3.0%   ArmRt_WindowBeltline
 1.0%   ArmRt_CantTell

44.8%   ElbLt_Armrest
26.9%   ElbLt_Torso
25.0%   ElbLt_Nothing
 4.9%   ElbLt_Other
 1.8%   ElbLt_LowerExt
 0.1%   ElbLt_CantTell
 0.1%   ElbLt_WindowBeltline

39.8%   ElbRt_Torso
25.6%   ElbRt_Nothing
23.8%   ElbRt_Armrest
 5.6%   ElbRt_WindowBeltline
 2.7%   ElbRt_LowerExt
 2.2%   ElbRt_Other
 1.1%   ElbRt_CantTell

50.5%   HandLt_LowerExt
48.1%   HandLt_Other
10.2%   HandLt_Nothing
 5.2%   HandLt_Torso
 1.8%   HandLt_Armrest
 0.9%   HandLt_CtrStack
 0.6%   HandLt_CantTell
 0.2%   HandLt_WindowBeltline

47.1%   HandRt_Other
40.7%   HandRt_LowerExt
10.3%   HandRt_Armrest
 9.7%   HandRt_Nothing
 3.7%   HandRt_Torso
 3.2%   HandRt_WindowBeltline
 1.2%   HandRt_CantTell
 0.3%   HandRt_CtrStack

56.1%   HandXLt_Nothing
22.8%   HandXLt_Other
13.9%   HandXLt_Phone
 4.4%   HandXLt_Drink
 2.9%   HandXLt_Food
 0.7%   HandXLt_CtrStack

56.5%   HandXRt_Nothing
25.2%   HandXRt_Other
12.9%   HandXRt_Phone
 3.0%   HandXRt_Drink
 2.4%   HandXRt_Food
 0.2%   HandXRt_CtrStack

77.4%   HtLt_OnAboveLap
13.8%   HtLt_ChestToNeck
 7.7%   HtLt_NeckHead
 0.7%   HtLt_Other

74.6%   HtRt_OnAboveLap
13.2%   HtRt_ChestToNeck
10.8%   HtRt_NeckHead
 0.9%   HtRt_Other

56.9%   Interaction_Talking
22.9%   Interaction_Nothing
13.4%   Interaction_Other
 9.9%   Interaction_Phone
 3.1%   Interaction_Food
 1.7%   Interaction_Drink
 1.1%   Interaction_Resting

70.0%   LtLeg_Lifted
49.3%   LtLegTouch_Nothing
41.4%   LtLegTouch_Console
27.8%   LtLeg_None
10.1%   LtLegTouch_Other
 3.1%   LtLegTouch_KneeBolster
 1.9%   LtLegTouch_CantTell
 1.6%   LtLeg_CantTell
 0.1%   LtLeg_CrossedUnder
 0.1%   LtLeg_CrossedOver

49.3%   LtLegTouch_Nothing
41.4%   LtLegTouch_Console
10.1%   LtLegTouch_Other
 3.1%   LtLegTouch_KneeBolster
 1.9%   LtLegTouch_CantTell

72.3%   RtLeg_Lifted
52.4%   RtLegTouch_Nothing
31.8%   RtLegTouch_Door
24.8%   RtLeg_None
 8.9%   RtLegTouch_Other
 7.2%   RtLegTouch_CantTell
 2.4%   RtLeg_CantTell
 2.2%   RtLegTouch_KneeBolster
 0.2%   RtLeg_CrossedOver
 0.0%   RtLeg_CrossedUnder

52.4%   RtLegTouch_Nothing
31.8%   RtLegTouch_Door
 8.9%   RtLegTouch_Other
 7.2%   RtLegTouch_CantTell
 2.2%   RtLegTouch_KneeBolster

APPENDIX C
Rare Events Not Otherwise Coded (only those appearing in >0.1% of frames)

Percent	Count	Event
3.607%	613	Cupholder Inside Center Cup
2.442%	415	Cupholder Inside Center Bottle
0.953%	162	FrontPass Hand Right HandLeftSelf
0.894%	152	FrontPass Hand Right Cigarette
0.841%	143	FrontPass Hand Left HandRightSelf
0.588%	100	FrontSeat Floor Center Bag
0.582%	99	FrontPass Hand Right DoorHandle
0.571%	97	FrontPass Lap Center Phone
0.500%	85	FrontPass Forearm Left Seatbelt
0.477%	81	FrontPass Lap Center Bag
0.441%	75	FrontPass Thigh Right ThighLeftSelf
0.435%	74	FrontPass Thigh Left ThighRightSelf
0.424%	72	FrontPass Hand Left Cigarette
0.418%	71	FrontPass Body Center Leaving
0.394%	67	FrontSeat Floor Left Bag
0.388%	66	FrontPass Hand Left OtherObject
0.388%	66	FrontPass Hand Left Face
0.365%	62	FrontPass Hand Left Seatbelt
0.347%	59	FrontPass Hand Right Seatbelt
0.341%	58	FrontPass Hand Left Bag
0.329%	56	FrontPass Elbow Left SeatbackPass
0.324%	55	Cupholder Inside Center Object
0.318%	54	FrontSeat Floor Center Backpack
0.294%	50	FrontPass Lap Center Purse
0.288%	49	FrontPass Mouth Inside Cigarette
0.288%	49	FrontPass Hand Right Bag
0.282%	48	FrontPass Lap Center Jacket
0.277%	47	FrontPass Lap Left Phone
0.253%	43	FrontPass Hand Right Face
0.241%	41	FrontPass Hand Right OtherObject
0.229%	39	FrontPass Lap Right Phone
0.218%	37	FrontPass Forearm Right Seatbelt
0.206%	35	Cupholder Inside Center Phone
0.200%	34	Cupholder Inside Center Box
0.194%	33	FrontPass Lap Center Notebook
0.194%	33	FrontPass Ear Right Earbud
0.188%	32	Cupholder Top Center Bottle
0.182%	31	FrontPass Thigh Left Bag
0.182%	31	FrontPass Hand Left Jacket

0.182%	31	Cupholder Top Center Phone
0.177%	30	FrontPass Lap Center Sweater
0.171%	29	FrontPass Thigh Left Cup
0.171%	29	FrontPass Hand Right SeatPass
0.171%	29	FrontPass Elbow Left DriverElbowRight
0.165%	28	FrontPass Hand Right Jacket
0.153%	26	FrontPass Lap Left Bag
0.153%	26	FrontPass Hand Right HeadPosterior
0.147%	25	FrontPass Thigh Right Bag
0.147%	25	FrontPass Lap Center OtherObject
0.147%	25	FrontPass Hand Left Paper
0.141%	24	Cupholder Inside Center Can
0.135%	23	FrontPass Hand Left ArmRightSelf
0.135%	23	FrontPass Forearm Left DriverForearmRight
0.135%	23	FrontPass Elbow Right Pillar
0.135%	23	FrontPass Ear Left Earbud
0.129%	22	FrontPass Lap Center Paper
0.129%	22	FrontPass Forearm Left Jacket
0.124%	21	FrontPass Lap Left Jacket
0.124%	21	FrontPass Hand Left SeatPan
0.124%	21	FrontPass Hand Left CoatPocket
0.118%	20	Cupholder Top Center Bag
0.118%	20	Consol Top Center Bag
0.112%	19	Consol Top Center Hat
0.106%	18	FrontPass Thigh Left Bottle
0.106%	18	FrontPass Hand Right Purse
0.106%	18	FrontPass Hand Right ArmLeftSelf
0.106%	18	FrontPass Hand Left HeadPosterior
0.106%	18	FrontPass Ear Right Phone
0.100%	17	FrontPass Lap Center Food
0.100%	17	FrontPass Hand Right Paper
0.100%	17	FrontPass Hand Left Phone
0.100%	17	FrontPass Hand Left Book
0.100%	17	FrontPass Forearm Right ForearmLeftSelf
0.100%	17	FrontPass Forearm Left ForearmRightSelf