Using GOMS and the Thinking Aloud Technique to infer driver states

David Käthner (DLR)

Julia Bühring (OvGU Magdeburg)

Klas Ihme (DLR)

Background: The Nature of Driving

Driving is

1. a satisficing task,
2. partially self-paced

↓

satisfying + suff**ice**

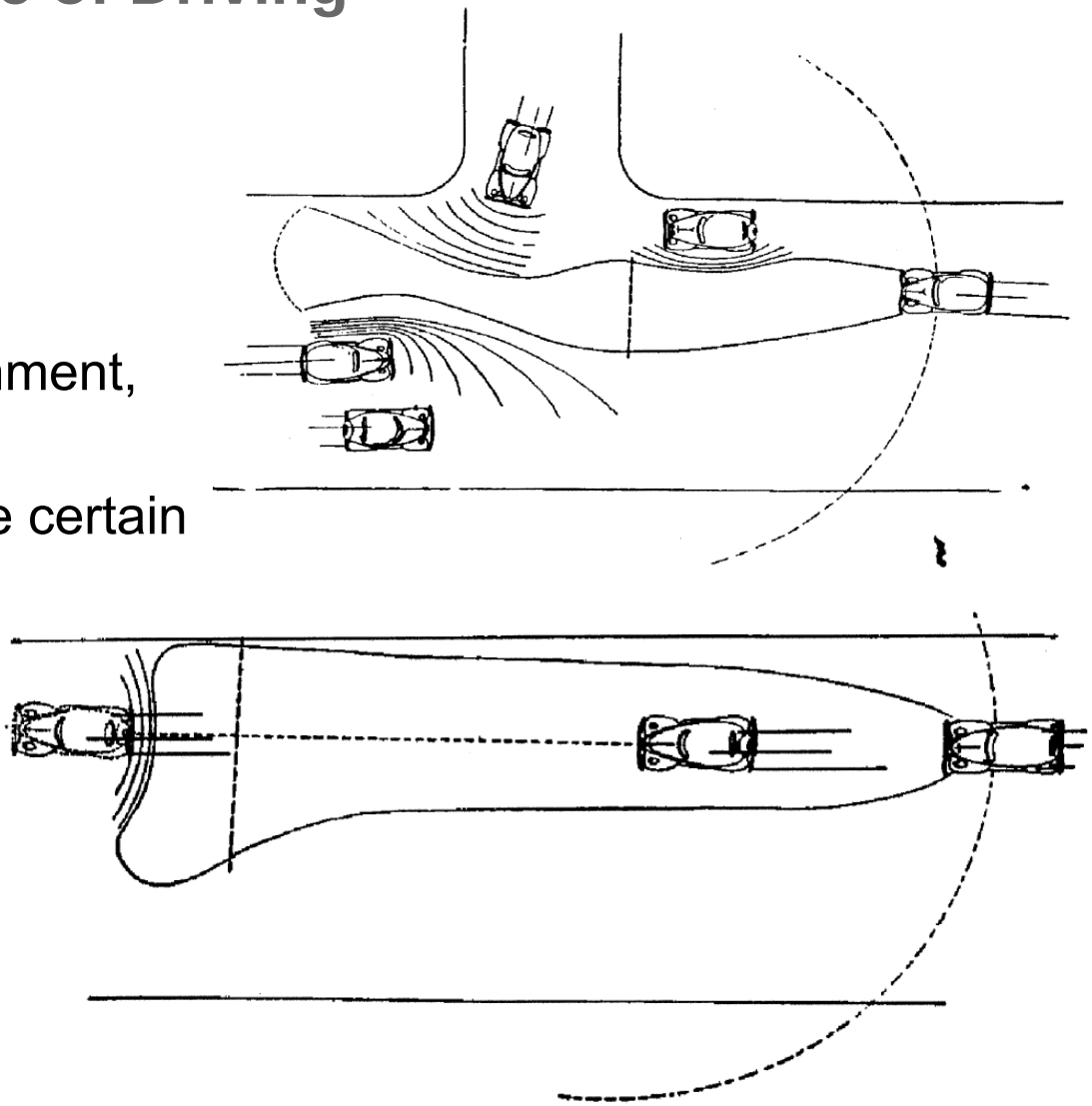
Kircher & Ahlstrom (2016): Minimum Required Attention.

Background: The Nature of Driving

Driving is

1. a "satisficing" task,
2. partially self-paced,
3. in a physical, dynamic environment,
4. largely unregulated,
5. where you can die if you make certain mistakes.

Gibson & Crooks (1938): A theoretical field analysis of automobile driving.



Driver states: Two Definitions

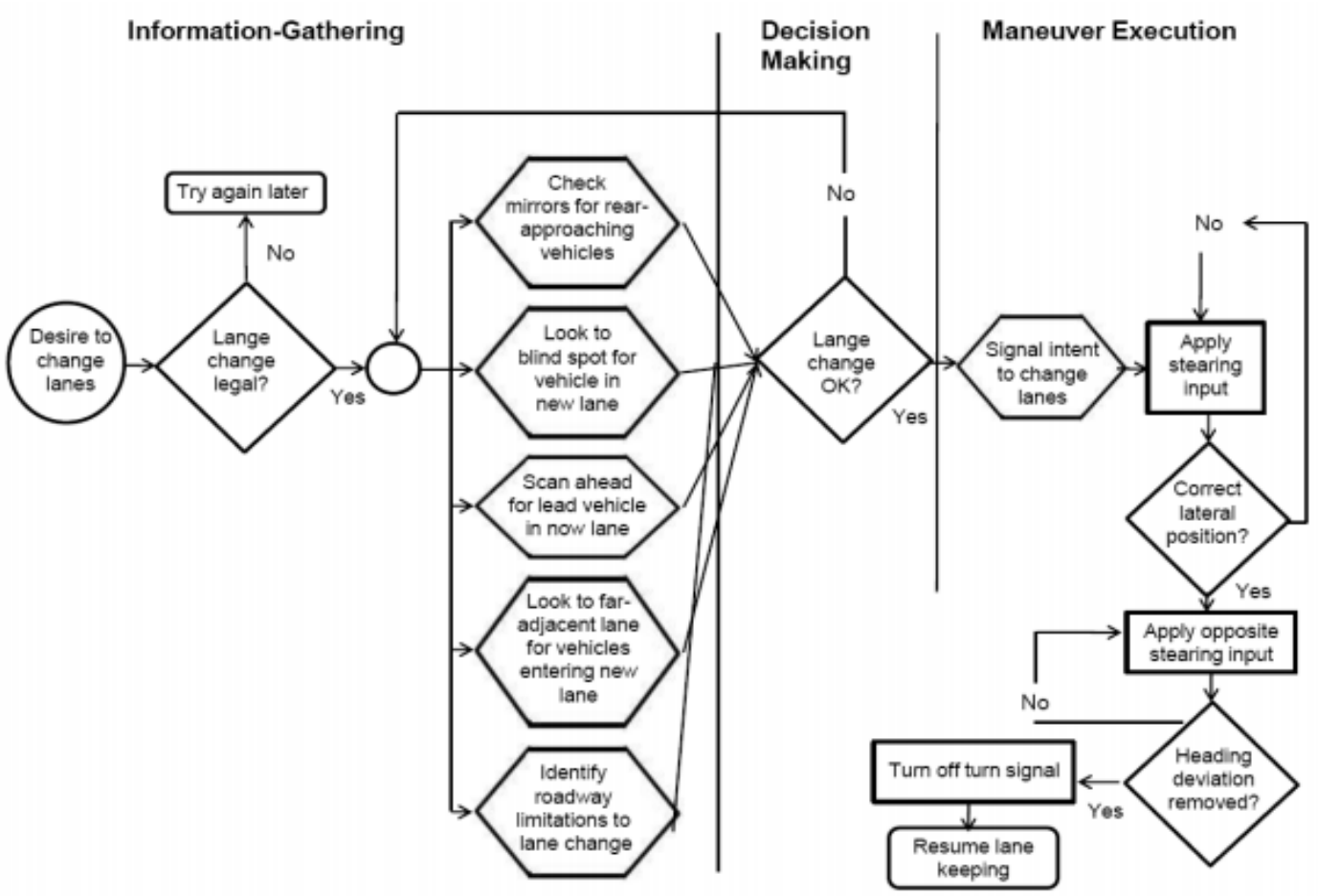
1. latent variable, "impairment level"
   - fatigue
   - drowsiness
   - (in)attention / distraction

e.g. Regan, Hallett, & Gordon (2011): Driver distraction and driver inattention

2. "state" as in "state diagram", usually on the tactical level
   - overtaking
   - lane change
   - lane following
   - car following

e.g. Cacciabue & Carsten (2011): A simple model of driver behaviour.

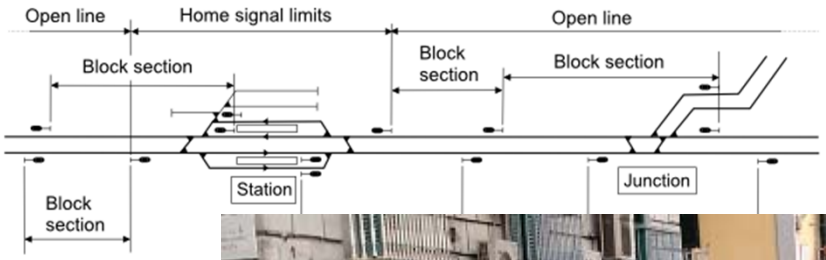
Problem: Is that really what is happening?



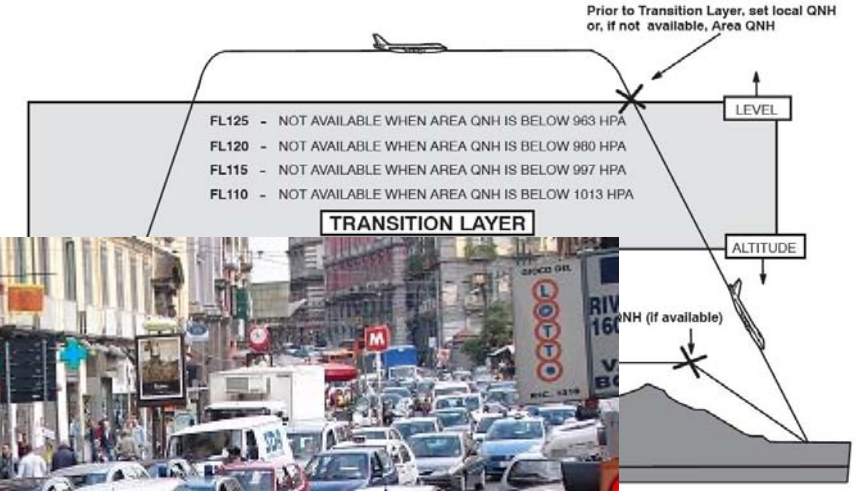
Chovan (1994). Examination of lane change crashes and potential IVHS countermeasures.

Problem: Slicing the World into Discrete States

States in the Railway system



States in the Aviation



Solution: Task Analysis, e.g. GOMS

Goals

- state of affairs to be achieved
- determine possible methods

Operators

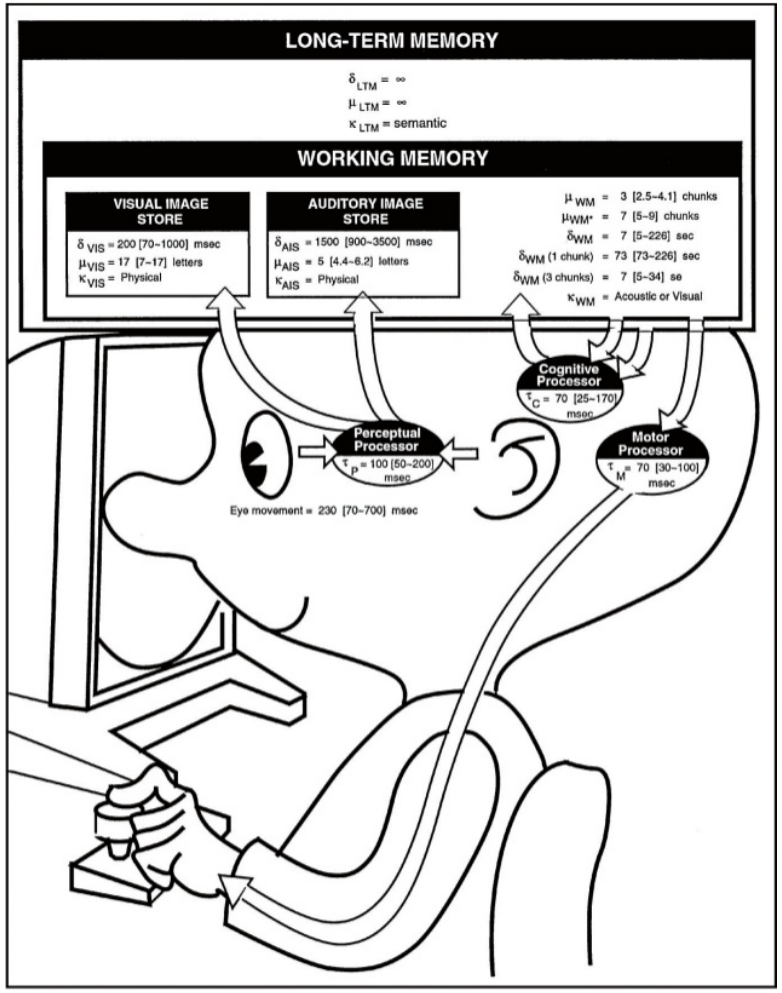
- cognitive, perceptual, motor acts
- physical or mental
- change state of user, environment

Methods

- procedure to accomplish goals
- consist of operators

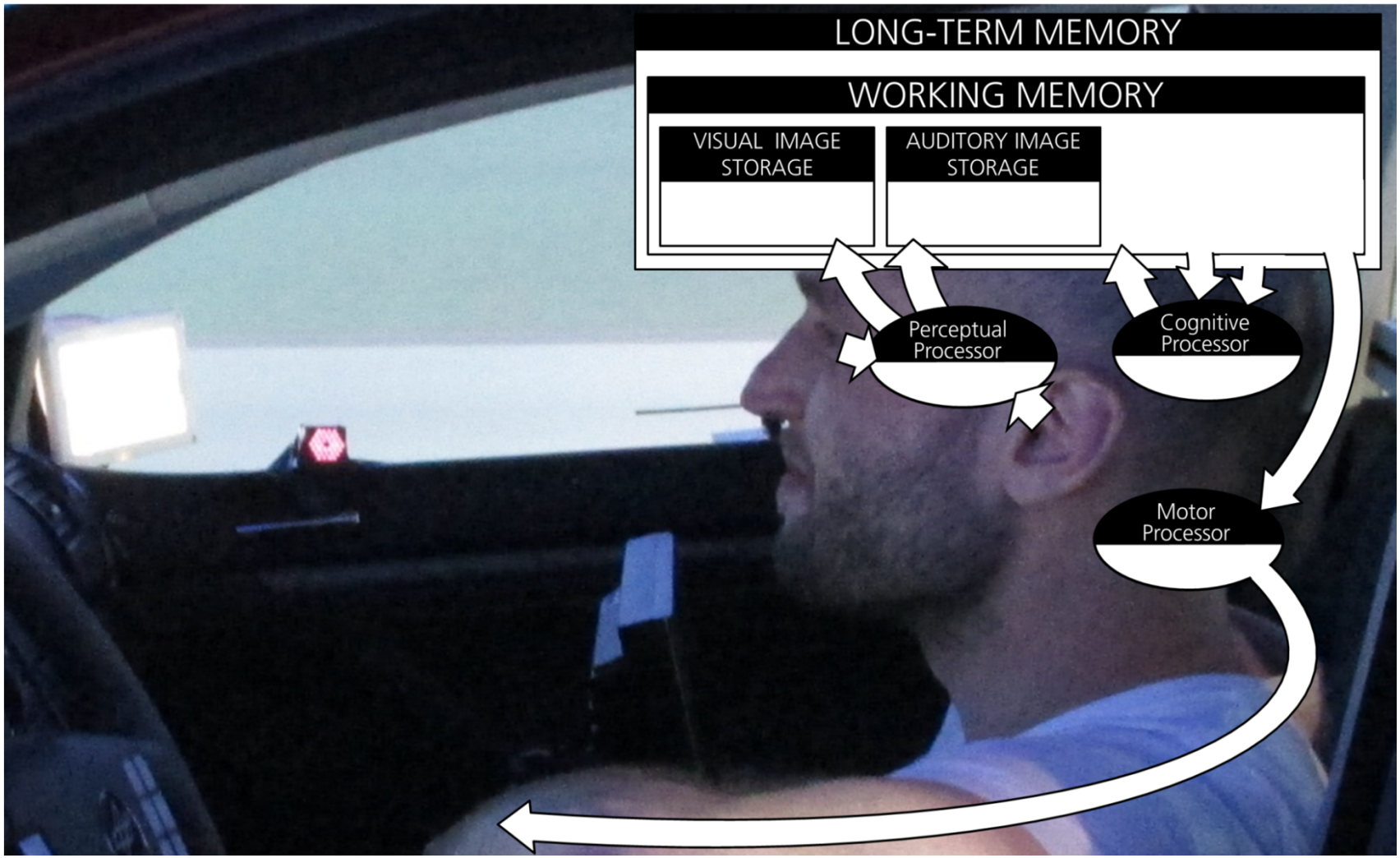
Selection Rules

- Which method to use?

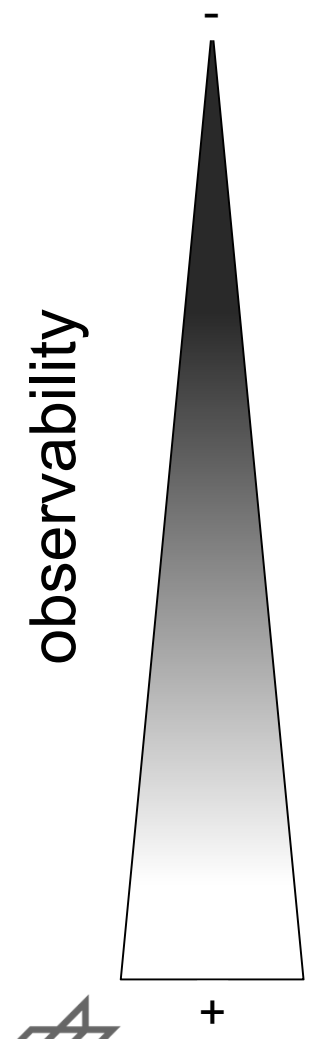


Card, Moran & Newell (1983): The Psychology of Human-Computer-Interaction.

The Model Human Driver



Going Bottom-Down: A GOMS for Driving



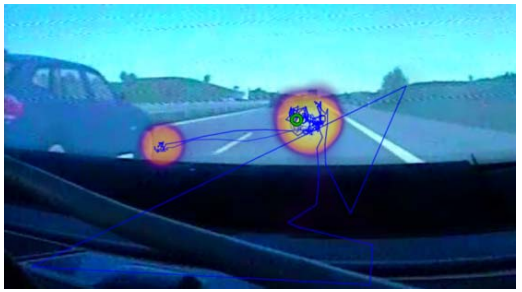
cognition **goals**

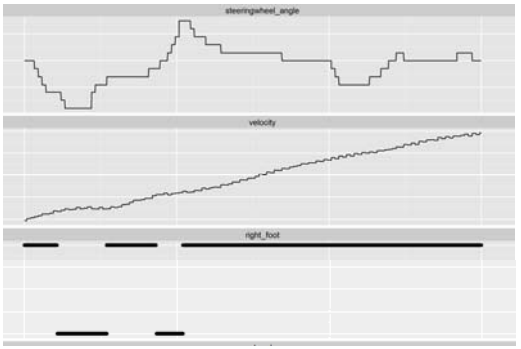
information uptake glances

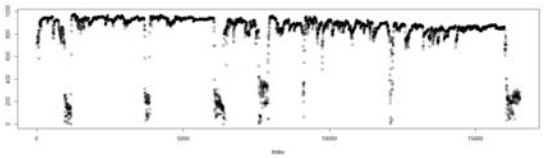
driving data

physical level

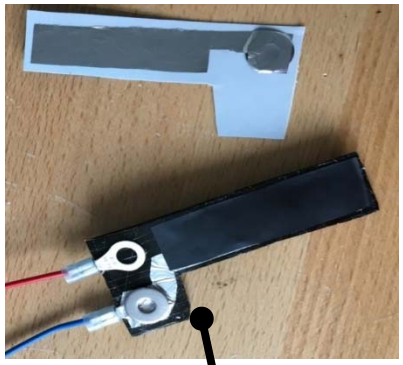
touch

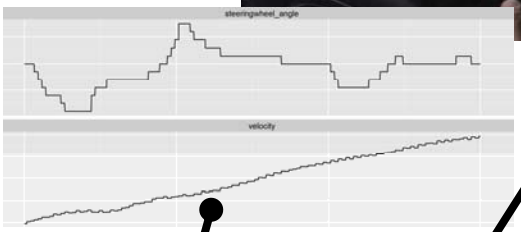






Data Fusion





[06:18] 0187 ich habe ihn jetzt doch überholt
[06:19] 0188 (0.7)
[06:20] 0189 06 vielleicht hat es jetzt was gebracht oder nicht
[06:22] 0190 ich habe in den seitenspiegel geguckt wie weit er denn jetzt hinter mir ist
[06:26] 0191 theoretisch könnte ich jetzt wieder links ausscheren
[06:28] 0192 (0.6)
[06:29] 0193 06 das mach ich jetzt einfach ma_al
[06:31] 0194 mit dem seitenspiegel
[06:32] 0195 und schulterblick
[06:33] 0196 er ist aber noch (.) weit genug entfernt
[06:35] 0197 aber der mini ja (.) de_er (-) ist fährt genauso langsam
[06:39] 0198 also irgendwie bringt das alles nichts
[06:41] 0199 (1.0)
[06:42] 0200 06 u_und muss ich ihm dann halt folgen
[06:45] 0201 (1.2)
[06:46] 0202 06 das geht auch
[06:47] 0203 dann bringt das rechts überholen auch nichts
[06:50] 0204 auch wenn es jetzt vielleicht erlaubt gewesen wäre
[06:52] 0205 oder auch nicht
[06:53] 0206 (0.5)
[06:53] 0207 06 das ist gerade die frage
[06:55] 0208 (0.6)
[06:55] 0209 06 der rechts ne_eben mir
[06:57] 0210 (1.3)
[06:58] 0211 06 hat für mich da eigen[illegible]ch nichts zu sagen
[07:00] 0212 aber ich halte trotz[illegible] alles im blick
[07:02] 0213 auch irgendwie durch d[illegible] rückspiegel

t	touch	vehicle data	gaze	goals	cognitive operators
1					
2					
...					
n					

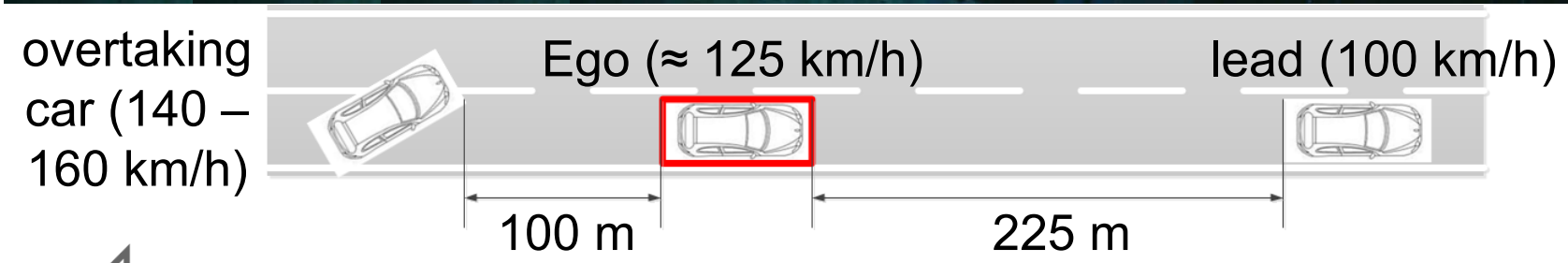
The Driving Simulator

DLR's Virtual Reality Lab

- 360° projection
- mock-ups or real car

Scenario 1 - Controlled

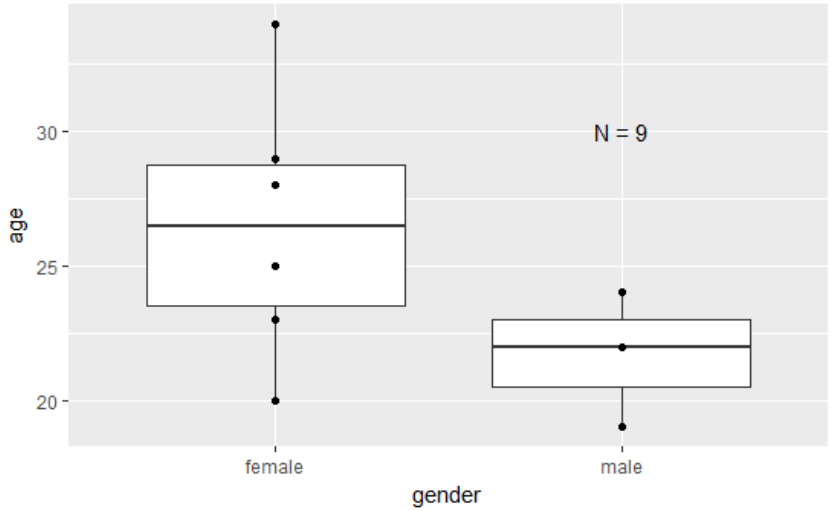
"Stay between 120 and 130 km/h"

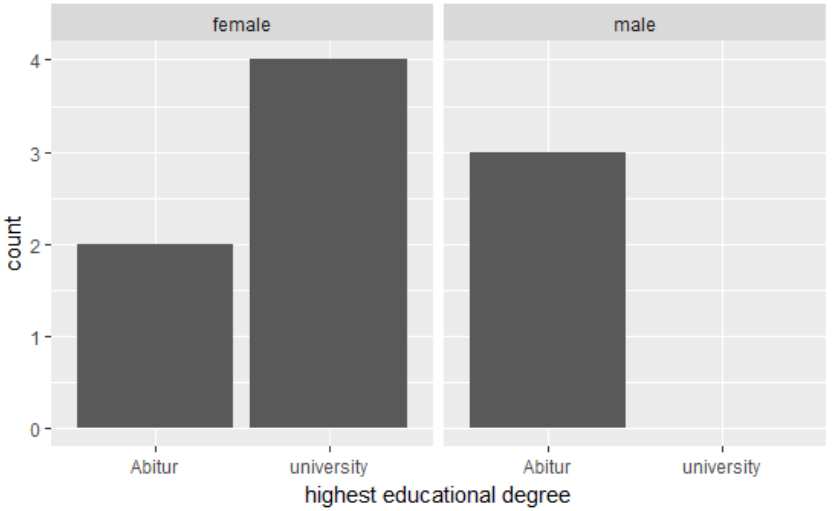


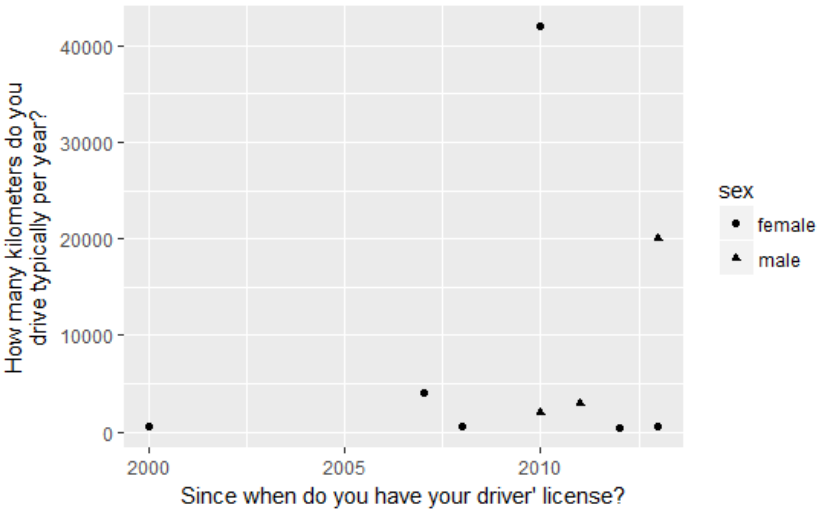
Scenario 2 - Realistic

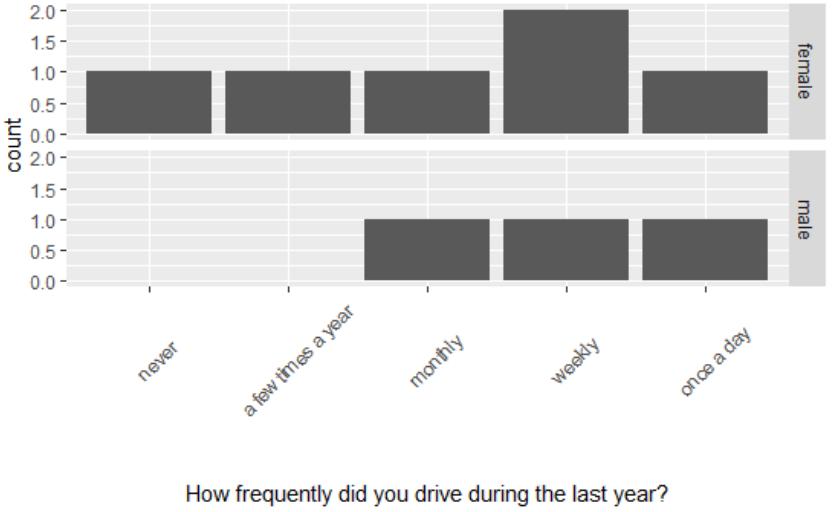
"Drive 110 - 150 km/h"

Subjects


N = 9
age
30
25
20
female
male
gender


female
male
count
4
3
2
1
0
Abitur
university
Abitur
university
highest educational degree

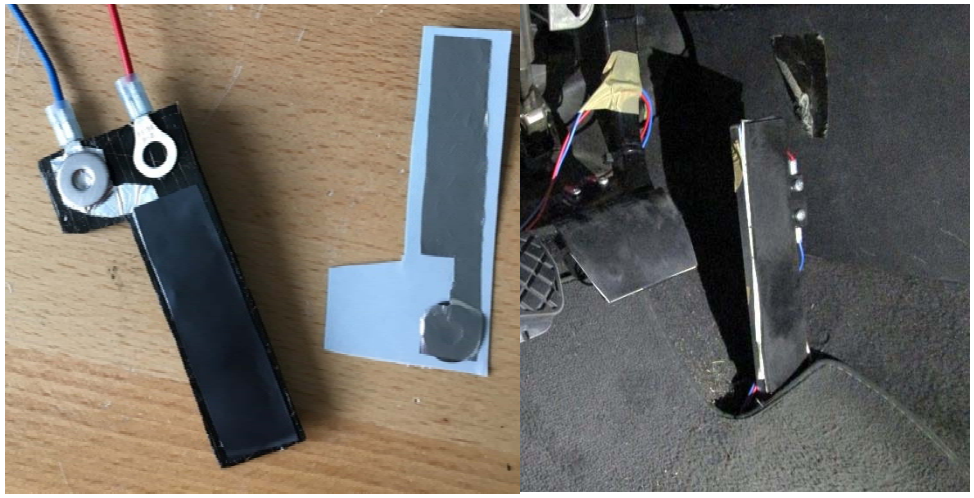

How many kilometers do you drive typically per year?
40000
30000
20000
10000
0
2000
2005
2010
Since when do you have your driver' license?
sex
female
male


count
2.0
1.5
1.0
0.5
0.0
female
male
never
a few times a year
monthly
weekly
once a day
How frequently did you drive during the last year?

Data Recording

thinking aloud: Webcam

pressure sensors

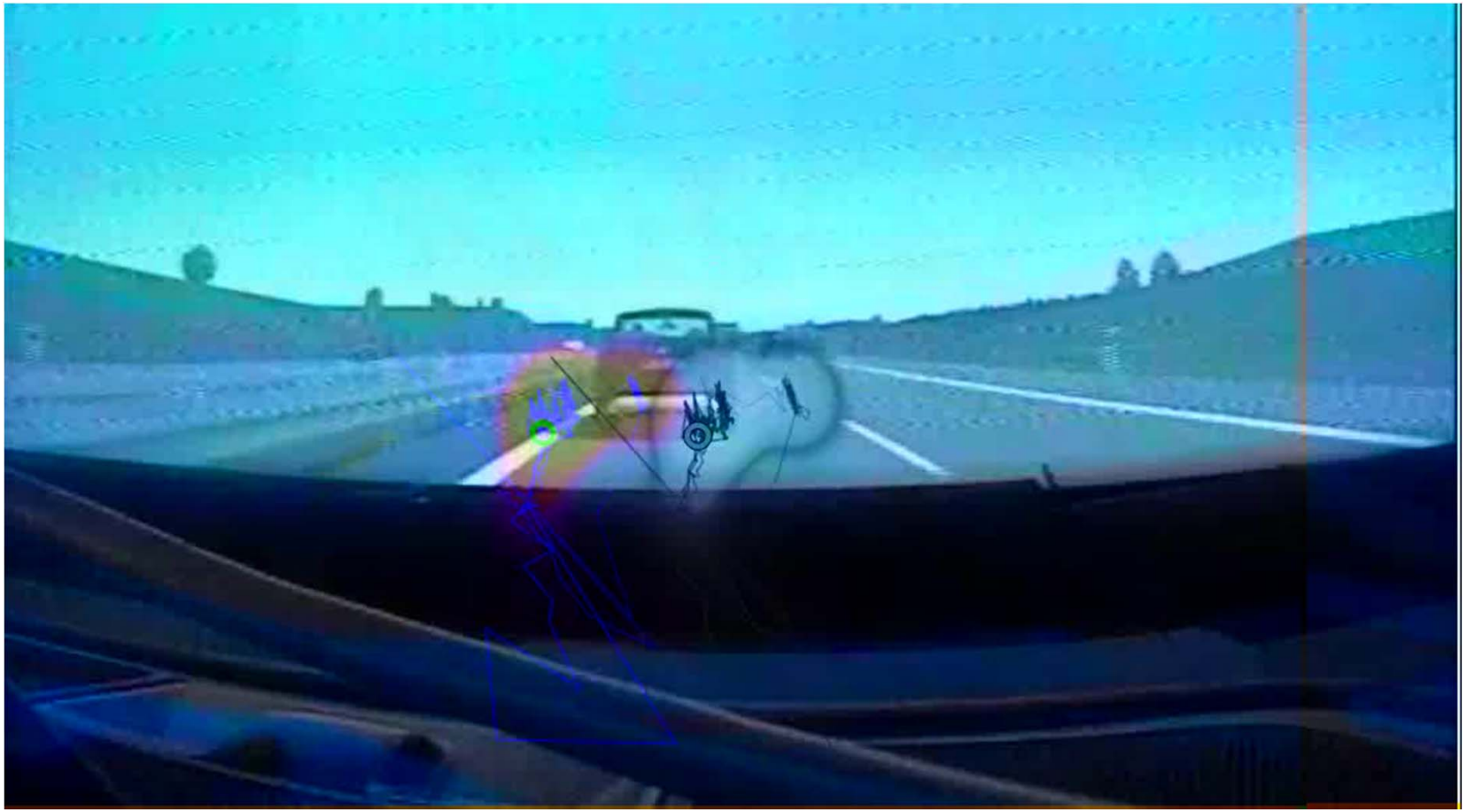


eye tracking: Smart Eye Pro

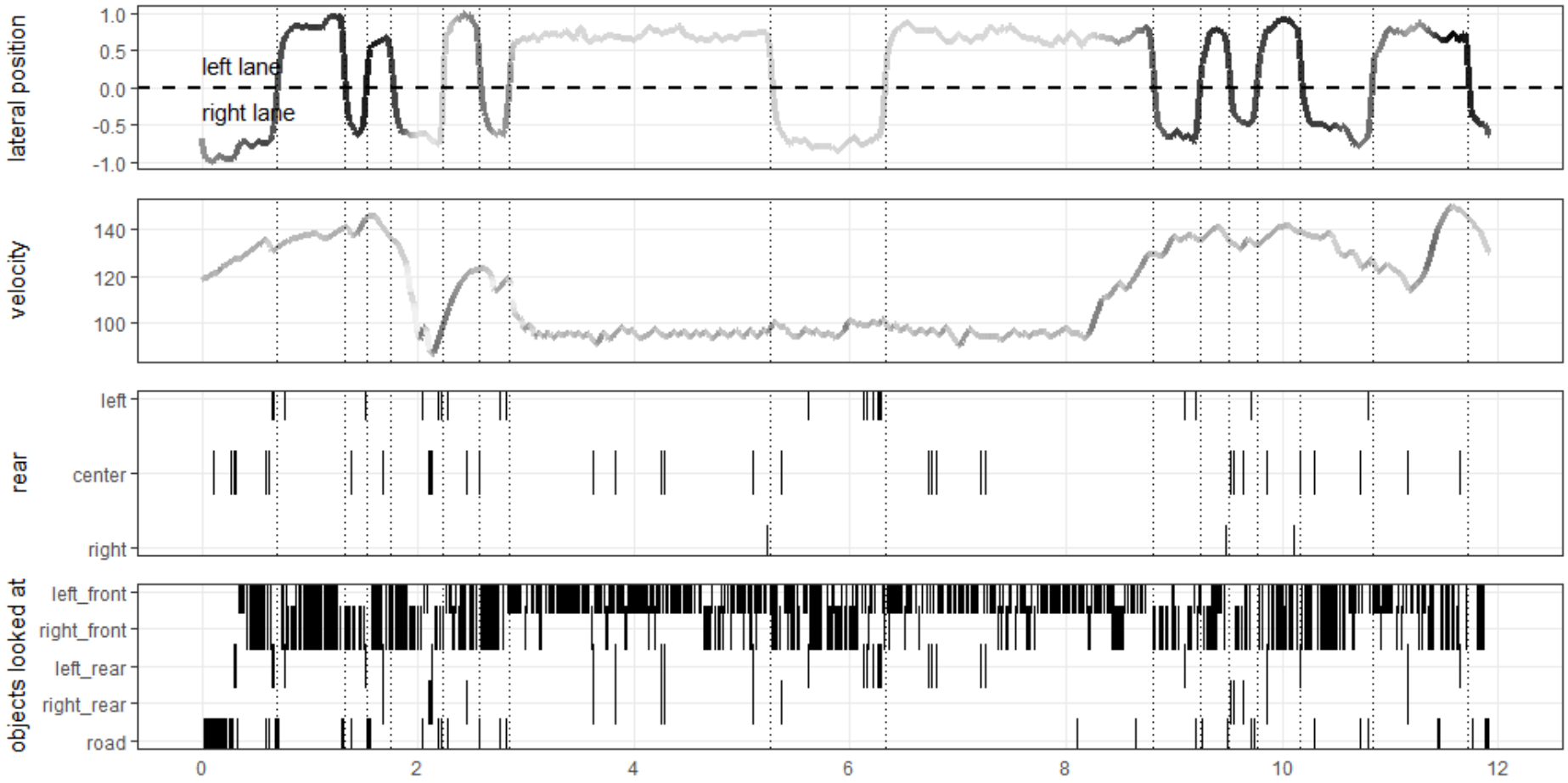
driving & simulation data

- velocity, acceleration
- positions
- steering (wheel) angle
- pedal input

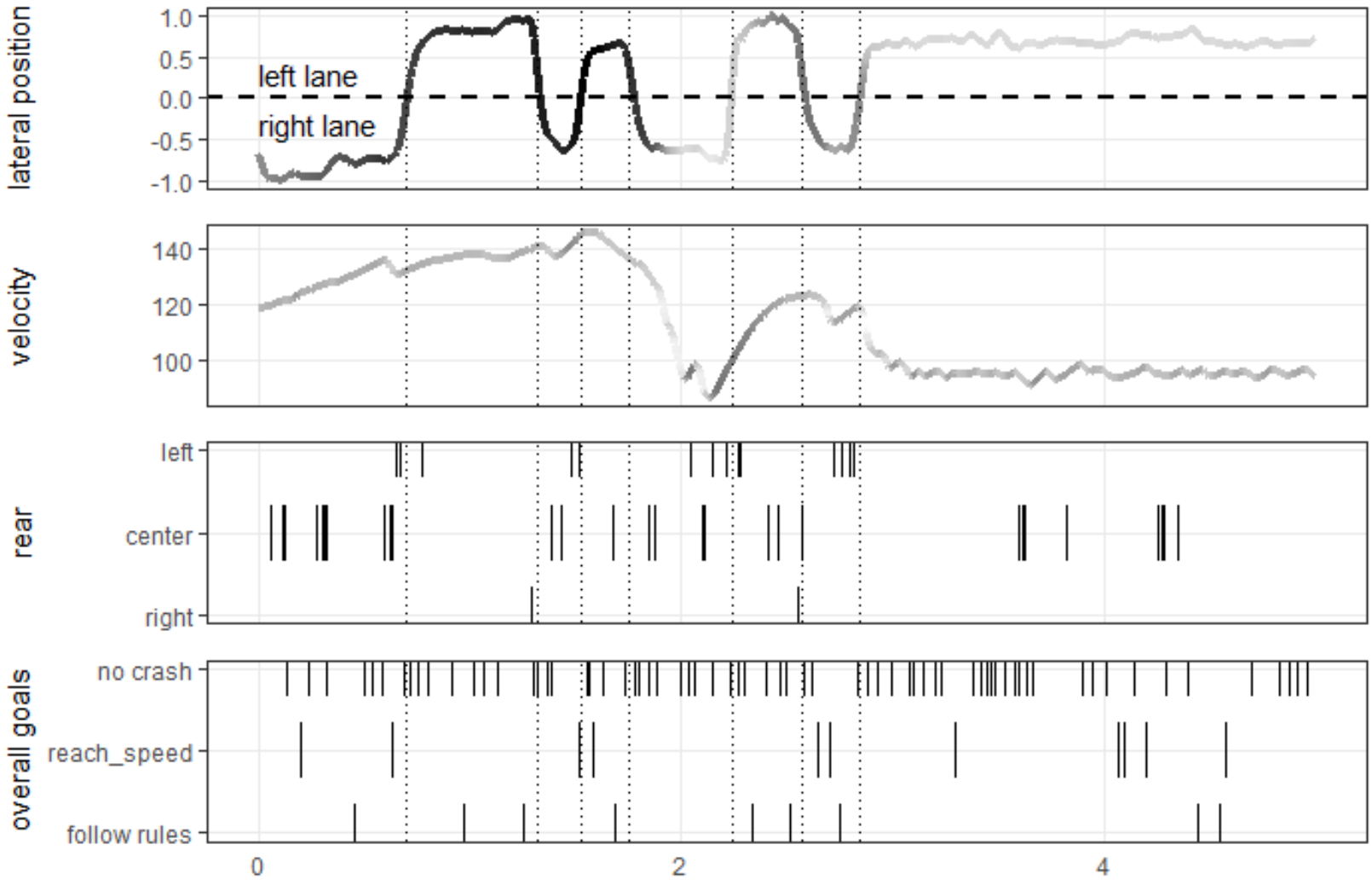
Data Recording



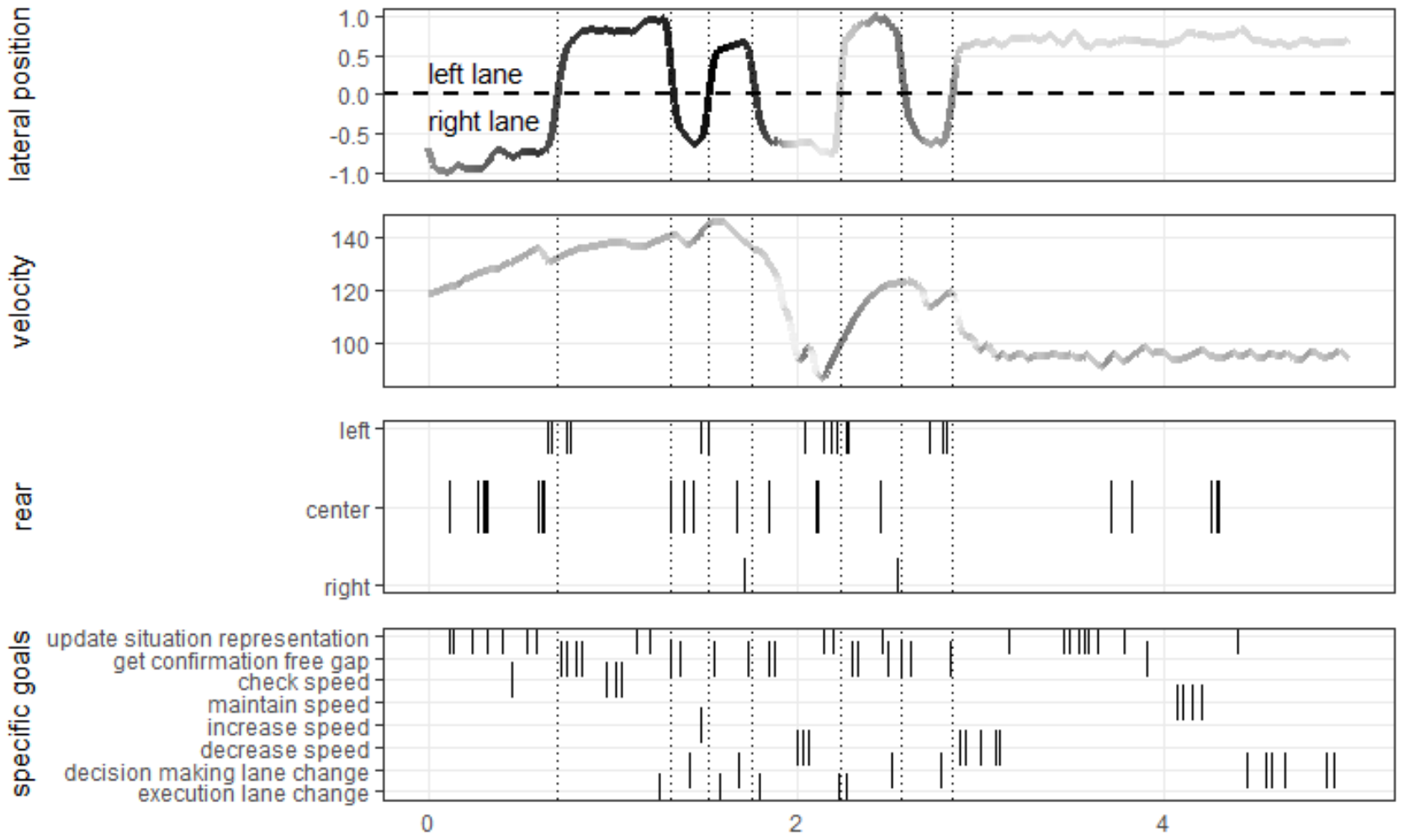
The Time Course of the Lane Changes



Overall Goals



More Specific Goals



Cognitive Operators

category	sub category
anticipating	vehicles in same lane will change speed
	vehicles in other lane will change speed
	lead vehicles will change lanes
	flow of traffic will change
evaluations	gap size
	distances to other vehicles, especially lead car
	accelerations of other vehicles
	situation ("nothing is happening")

Cognitive Operators

category	sub category
information retrieval	from LTM (traffic rules)
	from WM ("there is still a car back there")
decisions	change of velocity / acceleration
	lane change
	stay in lane
	follow lead car

Summary

What about driver states?

- useful to structure the task:
    1. information gathering
    2. decision making
    3. execution
- but no good fit with "what actually happens"

Problems with discrete states

- "It's the situation, stupid".
- *information gathering* and (a little less) *decision making* are what we do all the time. **That is the task.**
- states do not cover anticipation well

Summary + Outlook

Satisficing

- much of driving is "don't do X"
- does not clearly indicate what *should* be done

What's next?

- Sketch alternatives for a given situation.
- From the data: Why was *that* alternative chosen, not the others?

Thank you for your attention!