The Lane Change Task as a tool for driver distraction evaluation

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Lane Change Task

Developed within the Project ADAM (DaimlerChrysler, BMW)

Goal: Develop a method to evaluate driver distraction. Consider:

- Reliability
- Validity
- Objectivity
- simple
- low-cost

Lane Change Task

Strategy in method development: combine the advantages of classical approaches.

Dual task paradigm (work on two tasks simultaneously, performance in task 1 is index for capacity affordance of tasks 2)

- **Probe reaction time paradigm.** Response to additional stimulus. Reaction time is index for cognitive capacity. (RT with secondary task vs. RT without secondary task).
- **Driving simulation.** Drive in a more or less realistic scenario. Driving performance is an index for cognitive capacity. (Performance with secondary task vs. performance without secondary task).

Lane Change Task

Reaction time paradigm

+ condition exactly reproducable
+ condition under control
+ high frequency of measurements

= Reliability

Driving simulation

+ features of primary task resemble driving (cognitive, motoric, posture etc.)

= Validity

Standard consumer equipment
PC+Monitor
Game steering wheel

= low cost

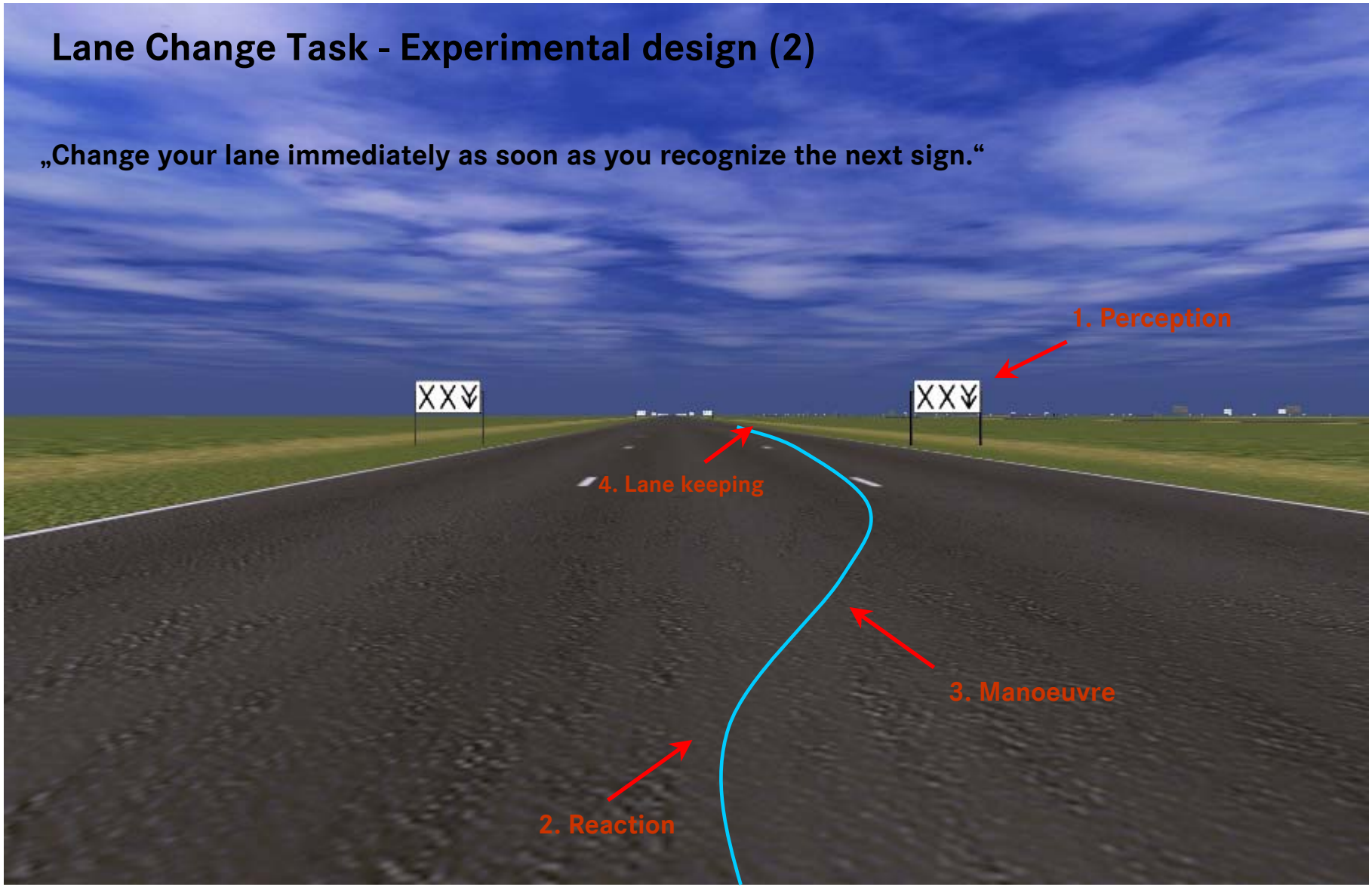
Standardized test plan
+ simple experimental plan
+ short testing
+ standardized analysis

= simple

Lane Change Task - Experimental design (1)

Dual-task situation.

The subjects have to drive in the simulated driving task while they perform a secondary task.


Lane Change Task - Experimental design (2)
„Change your lane immediately as soon as you recognize the next sign.“
1. Perception
4. Lane keeping
3. Manoeuvre
2. Reaction

Lane Change Task - Experimental design (3)

„Change your lane immediately as soon as you recognize the next sign.“

Velocity: constant 60 km/h

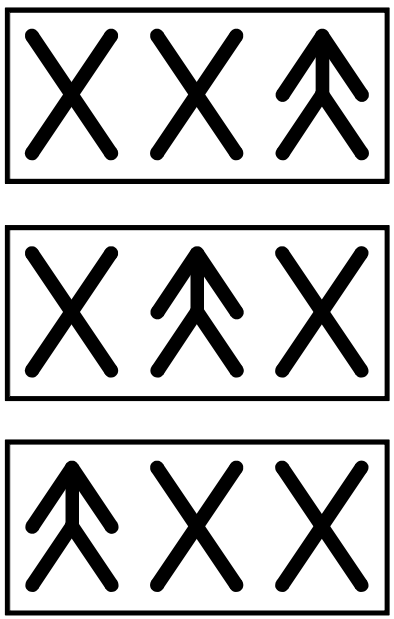
Distance between signs: M=150 (140-188 m, exponentially distr.)

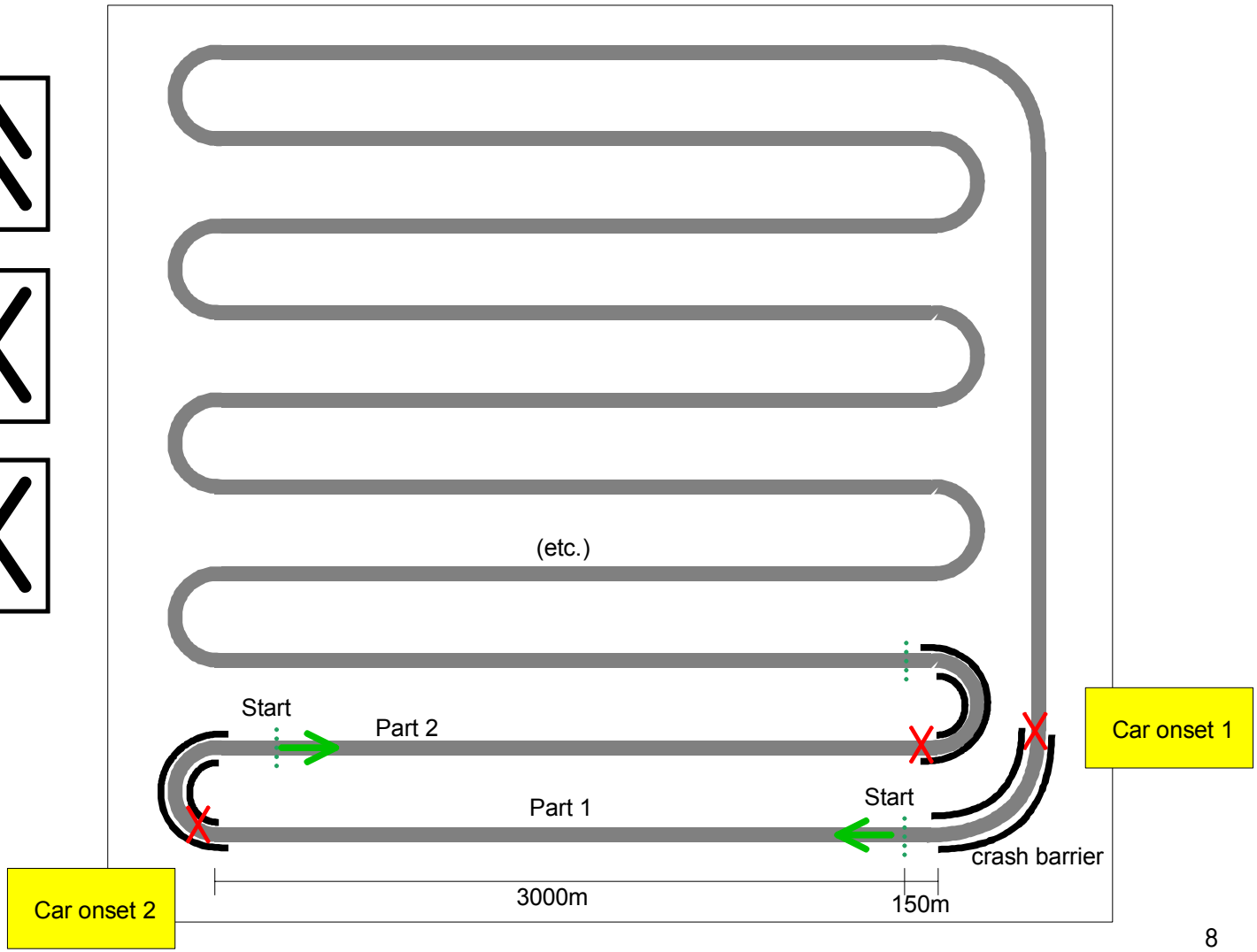
Duration: ~3 min.

Lane Change:

From lane \ to lane	1	2	3
1	0	3	3
2	3	0	3
3	3	3	0

Lane Change Task - Experimental Design (4)





Lane Change Task - Example

Lane Change Task - Procedure

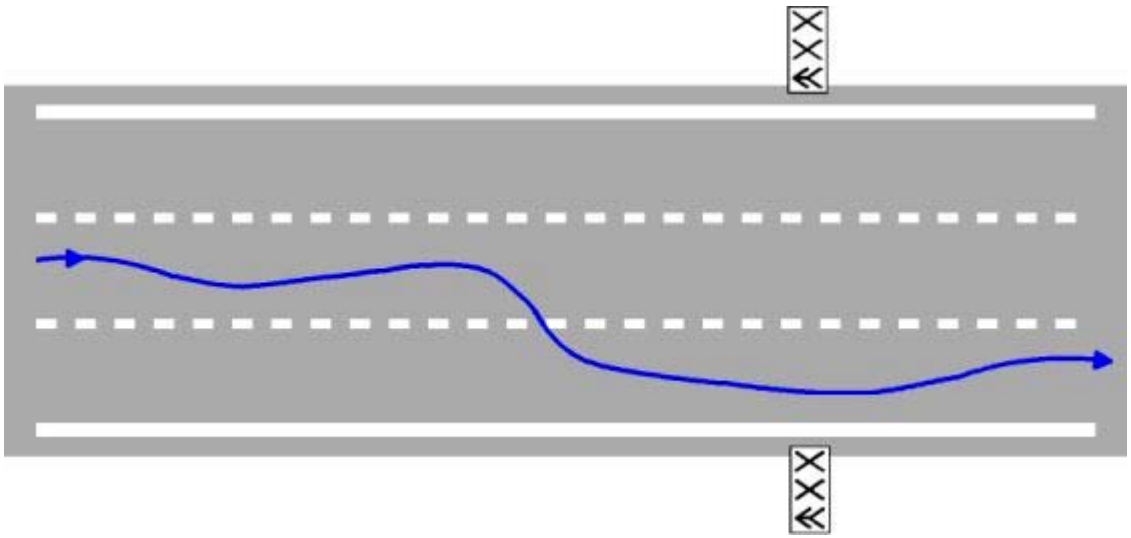
1.	**Primary Task**	**3 min**
1.	Secondary Task #1	3 min
1.	Secondary Task #1 + Primary Task	3 min
2.	Secondary Task #2	3 min
2.	Secondary Task #2 + Primary Task	3 min
3.	Secondary Task #3	3 min
3.	Secondary Task #3 + Primary Task	3 min
4.	Secondary Task #4	3 min
4.	Secondary Task #4 + Primary Task	3 min
2.	**Primary Task**	**3 min**
5	Secondary Task #1	3 min
5	Secondary Task #1 + Primary Task	3 min
6.	Secondary Task #2	3 min
6.	Secondary Task #2 + Primary Task	3 min
7.	Secondary Task #3	3 min
7.	Secondary Task #3 + Primary Task	3 min
8.	Secondary Task #4	3 min
8.	Secondary Task #4 + Primary Task	3 min
3.	**Primary Task**	**3 min**

n= 45 subjects

8 out of 12 secondary tasks per subject

Lane Change Task - Analysis

Position on the lane is recorded.



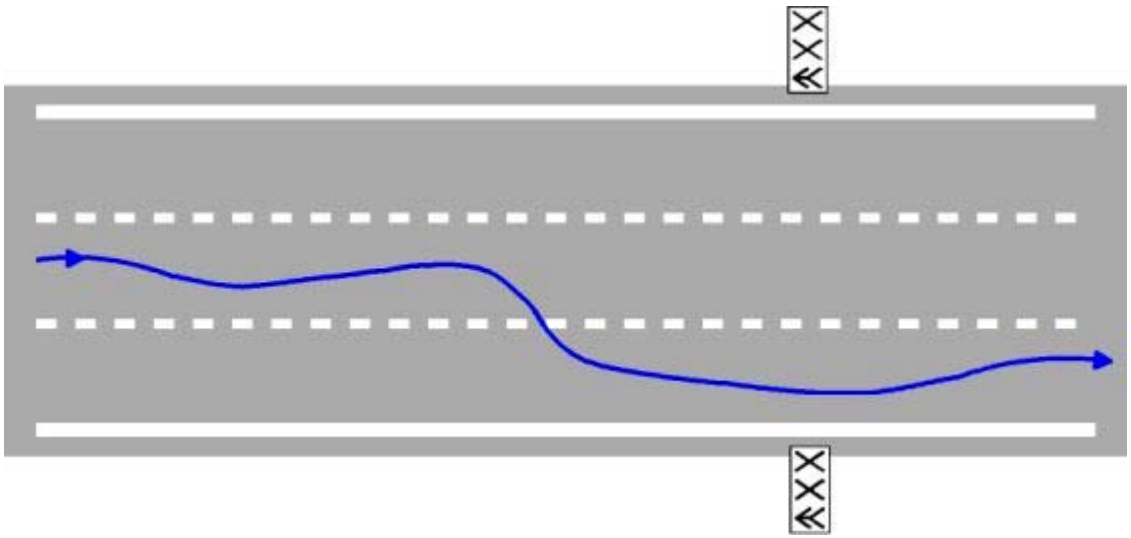
First approach:

1. fit model to measure “RT”
2. count missed signs
3. measure lane keeping performance
4. combine all measures

→ effortful and complicated

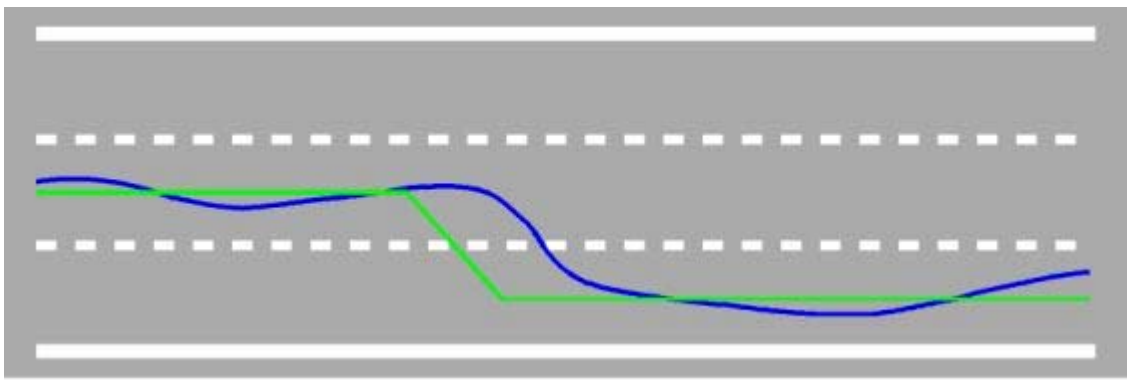
Lane Change Task - Analysis (1)

Position on the lane is recorded.



Lane Change Task - Analysis (2)

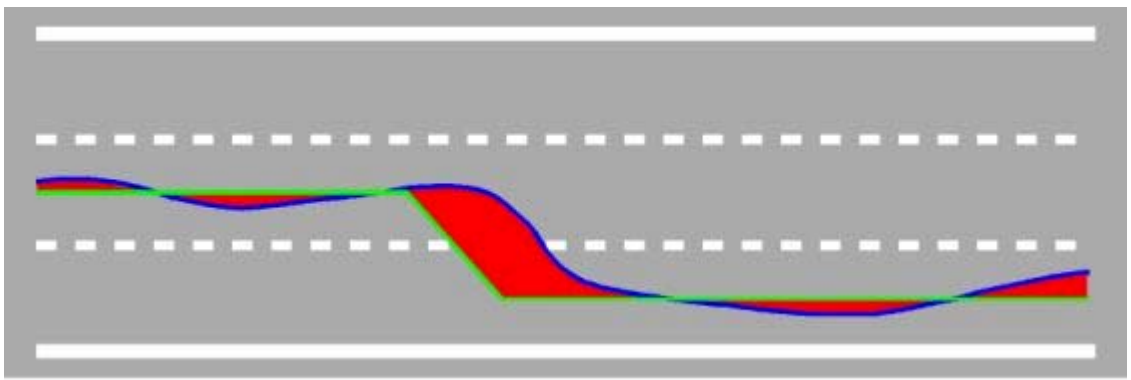
A simple normative model is used to assess driving performance



Note that all parameters of this model are fixed. That is, no fitting of the model to the behavioral data is necessary. The only parameters of the model are the onset of lane change (distance to sign) and the slope. These parameters can be set more or less arbitrary.

Lane Change Task - Analysis (3)

Area indicates driving quality.



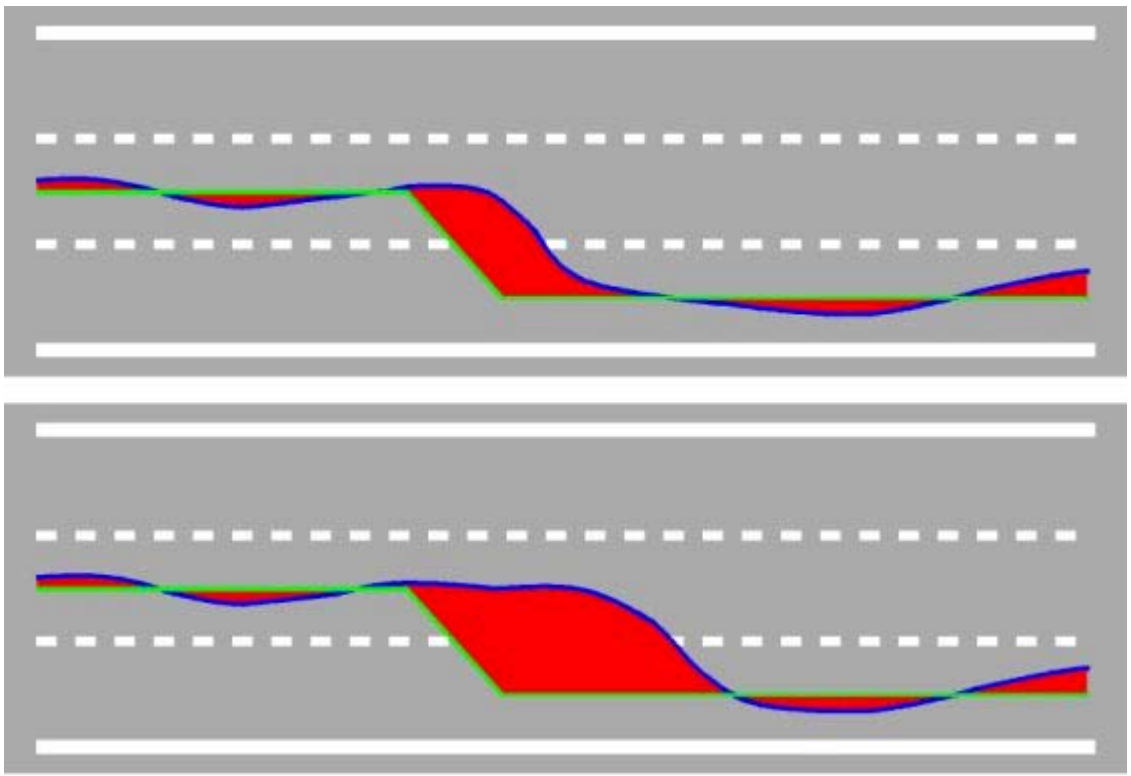
The area is sensitive to

- **Perception (missed sign)**
- **Reaction**
- **Manoeuvre**
- **Lane keeping**

This comparison of the behavioral data to the normative model provides one single index of performance which allows automatic and objective analysis.

Lane Change Task - Analysis (4)

Response: impact on area



Early response

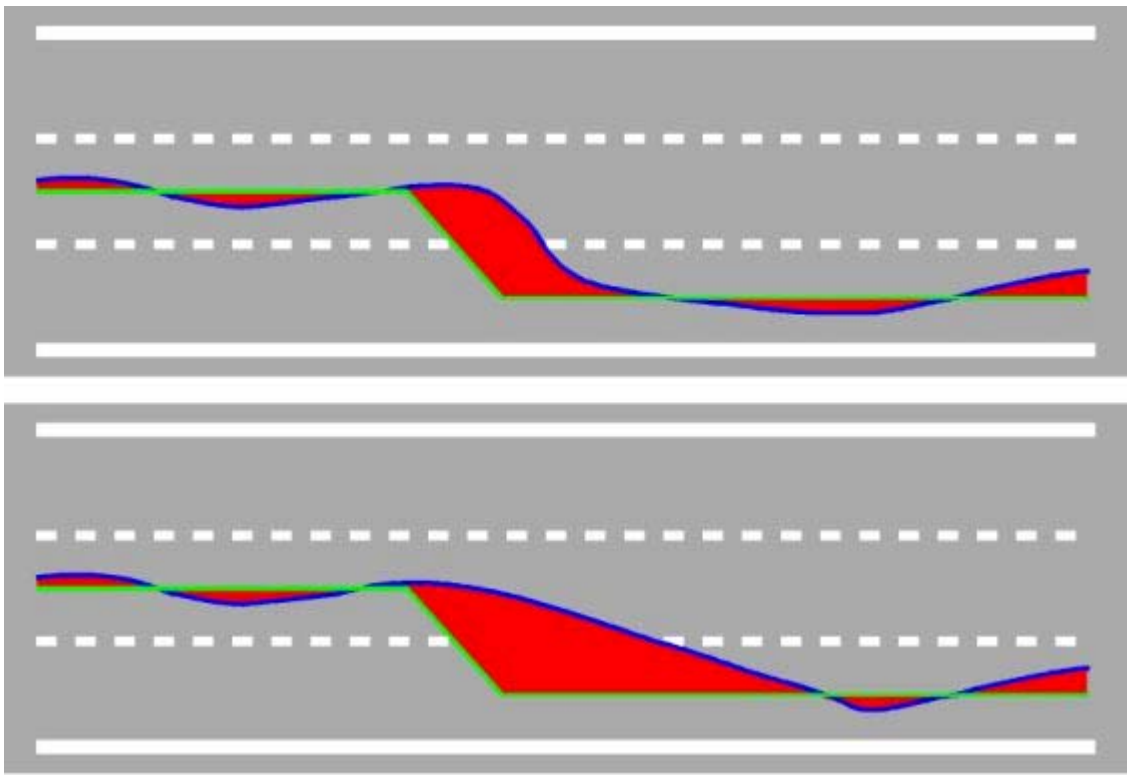
= small area

Late response

= big area

Lane Change Task - Analysis (5)

Manoeuvre: impact on area



Good manoeuvre

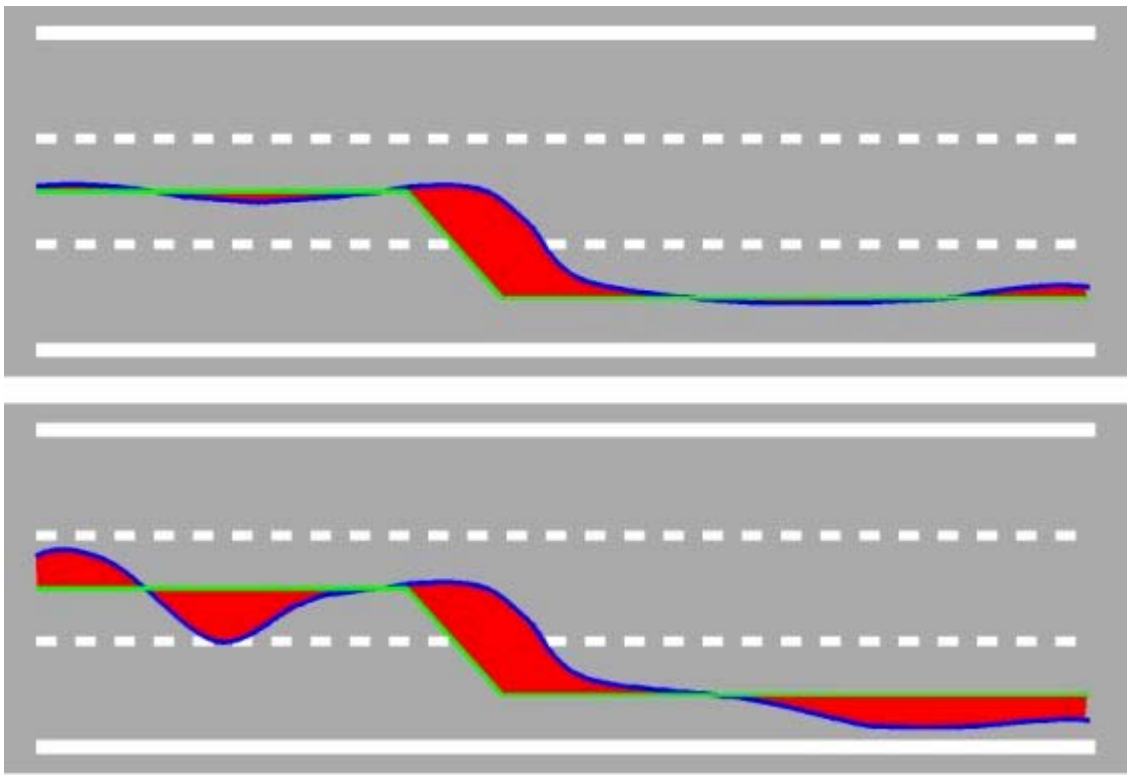
= small area

Bad manoeuvre

= big area

Lane Change Task - Analysis (6)

Lane keeping: impact on area



Good lane keeping

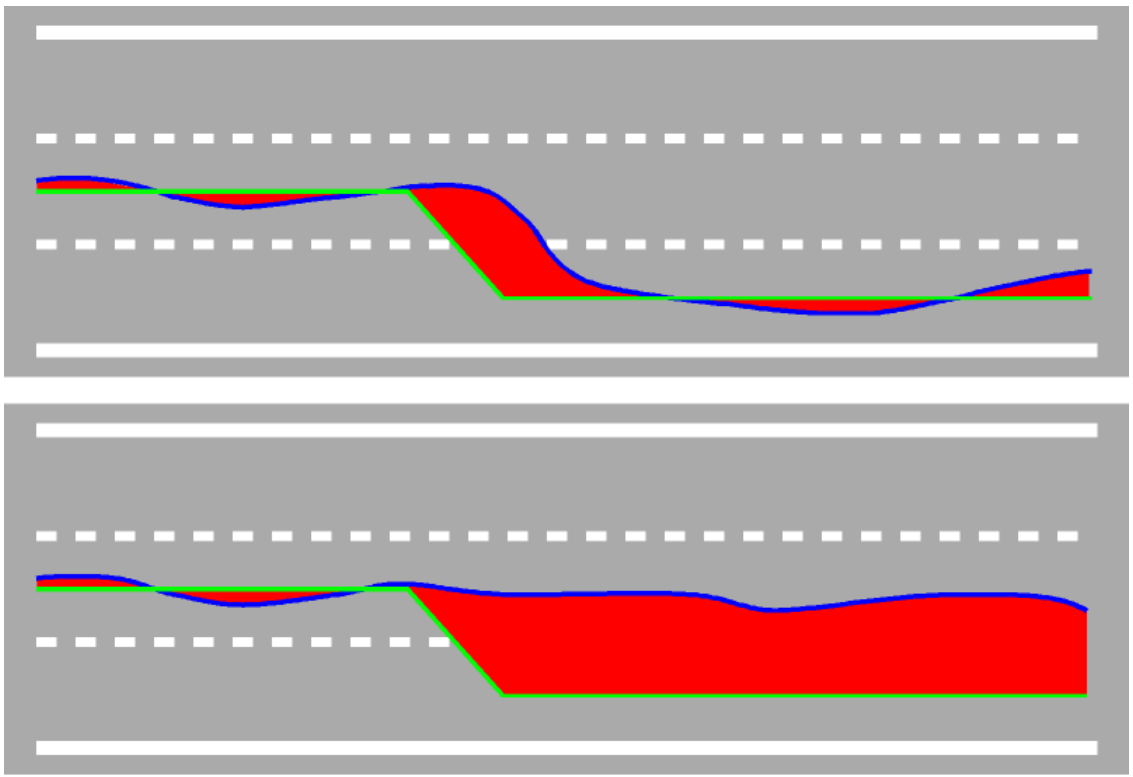
= small area

Bad lane keeping

= big area

Lane Change Task - Analysis (7)

Perception (missed sign): impact on area



Response to sign

= small area

Missed sign

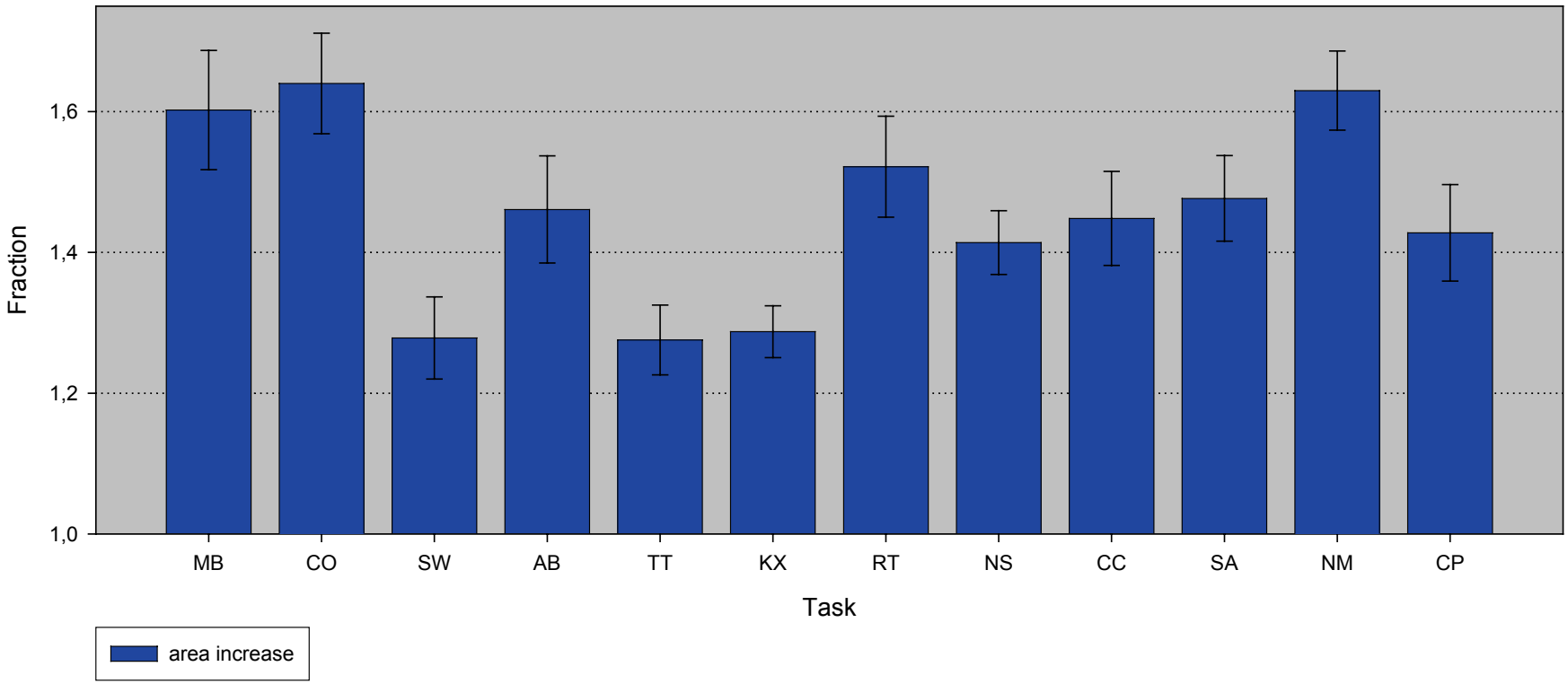
= big area

Lane Change Task - Result (Principle)

Area increase:

$$\frac{\text{Area with secondary task}}{\text{Area without secondary task}}$$

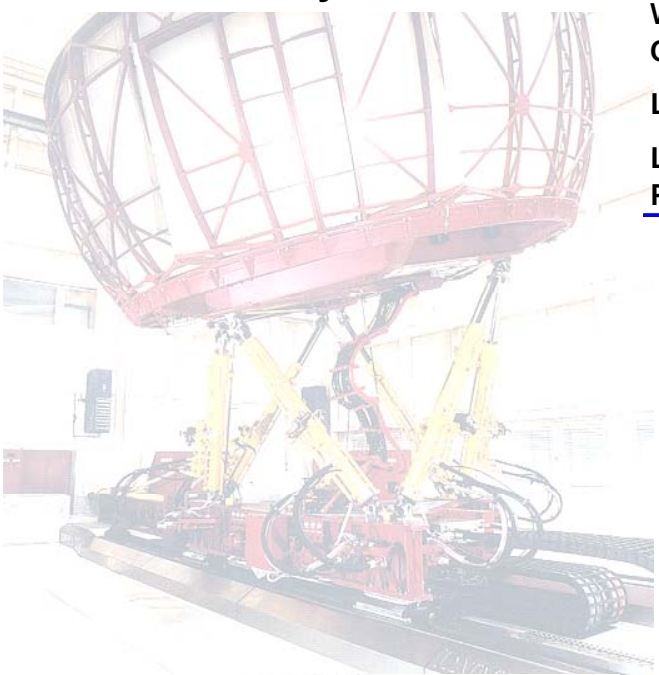
Lane Change Task - area increase

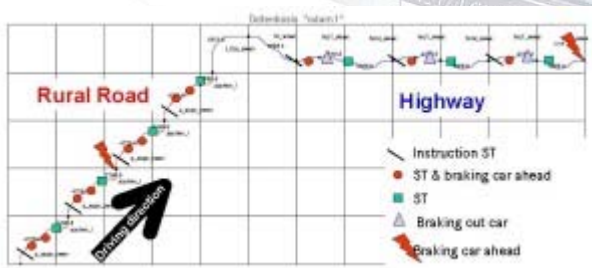


MB	Map Book	RT	Radio Tuning
CO	Coins	NS	Navigation Speller
SW	Unwrap Sweets	CC	Change Cassette
AB	Address Book	SA	Sound Adjustment
TT	Talk on Telephone	NM	Navigation Map
KX	Kleenex	CP	Cell Phone

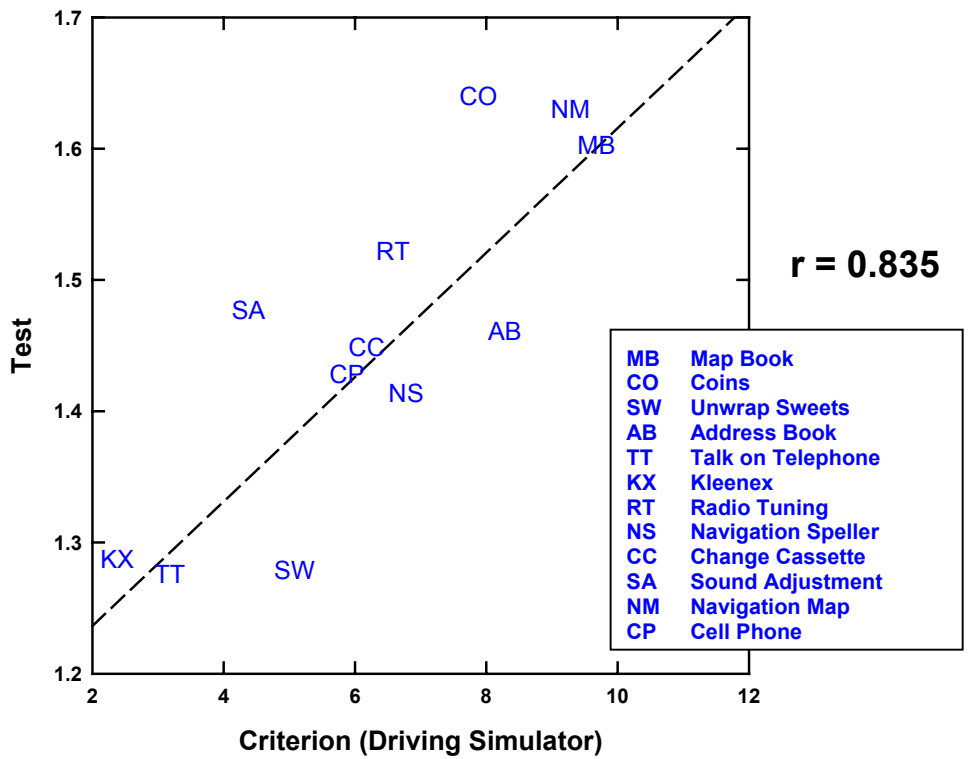
Lane Change Task

Moving base driving simulator Berlin
n = 85 subjects
Same 12 secondary tasks





Measure	
Workload	Subjective rating
Glance Behavior	Percentage glances outside
Lateral Control Behavior	Error Direction (max, sd), Lateral Acceleration (max, sd), Steering Wheel Angle (sd), TLC (min, mn, sd), Yaw Velocity
Longitudinal Control Performance	TTC (min), speed (sd, difference before-during ST), amount events distance to leading vehic < 5 sec,

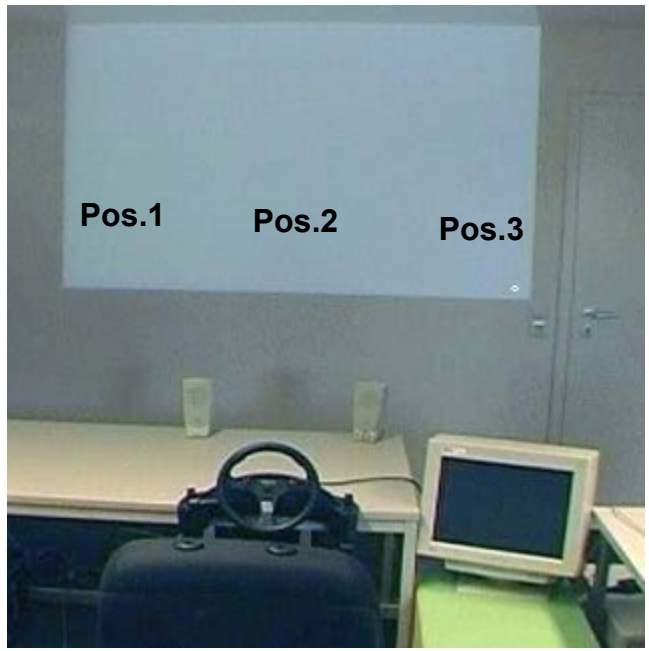


Basics of Lane Change Task and Peripheral Detection Task

Lane Change Task

Lane-Change-Task

Peripheral-Detection-Task



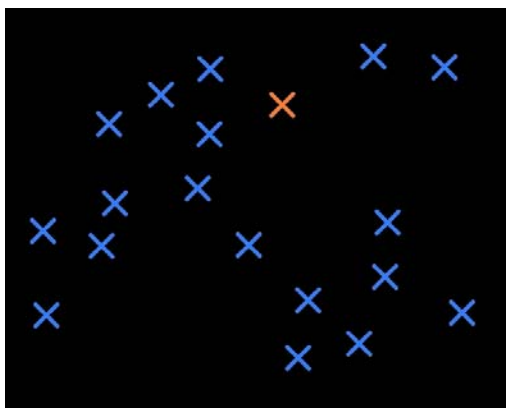
Randomly one of three stimulus locations;
Stimulus duration: 2 s
Inter-Stimulus-Interval: 2-4 s (random)
Response: foot pedal press

Lane Change Task

Visual task

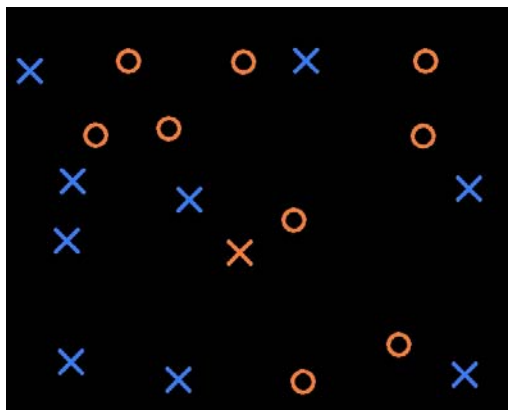
Find brown „X“ or blue „O“

Feature search



easy

Conjunction search



difficult

Details:

- Subject responds by saying „X“ or „O“. Reaction time is recorded.
- Experimenter marks response with keypress (X or O); about 500 ms
- Next screen immediately after experimenters input.
- Duration 3 minutes.

Cognitive task

„Count from [...] forwards in steps of 2“

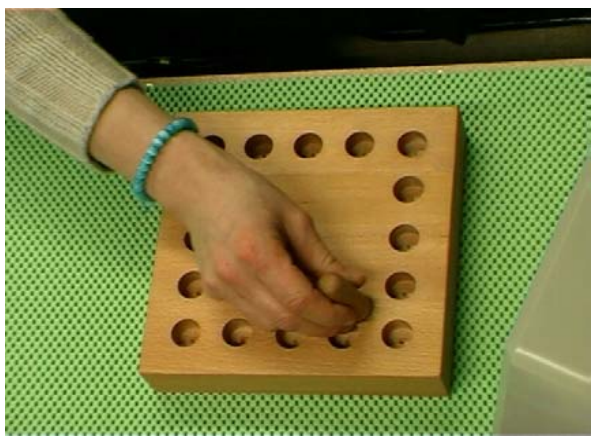
easy

„Count from [...] backwards in steps of 7“

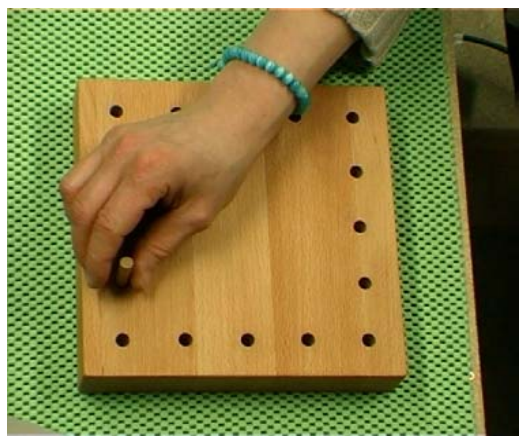
difficult

Motor task

Put stick clockwise in every hole and turn it without looking at the board !

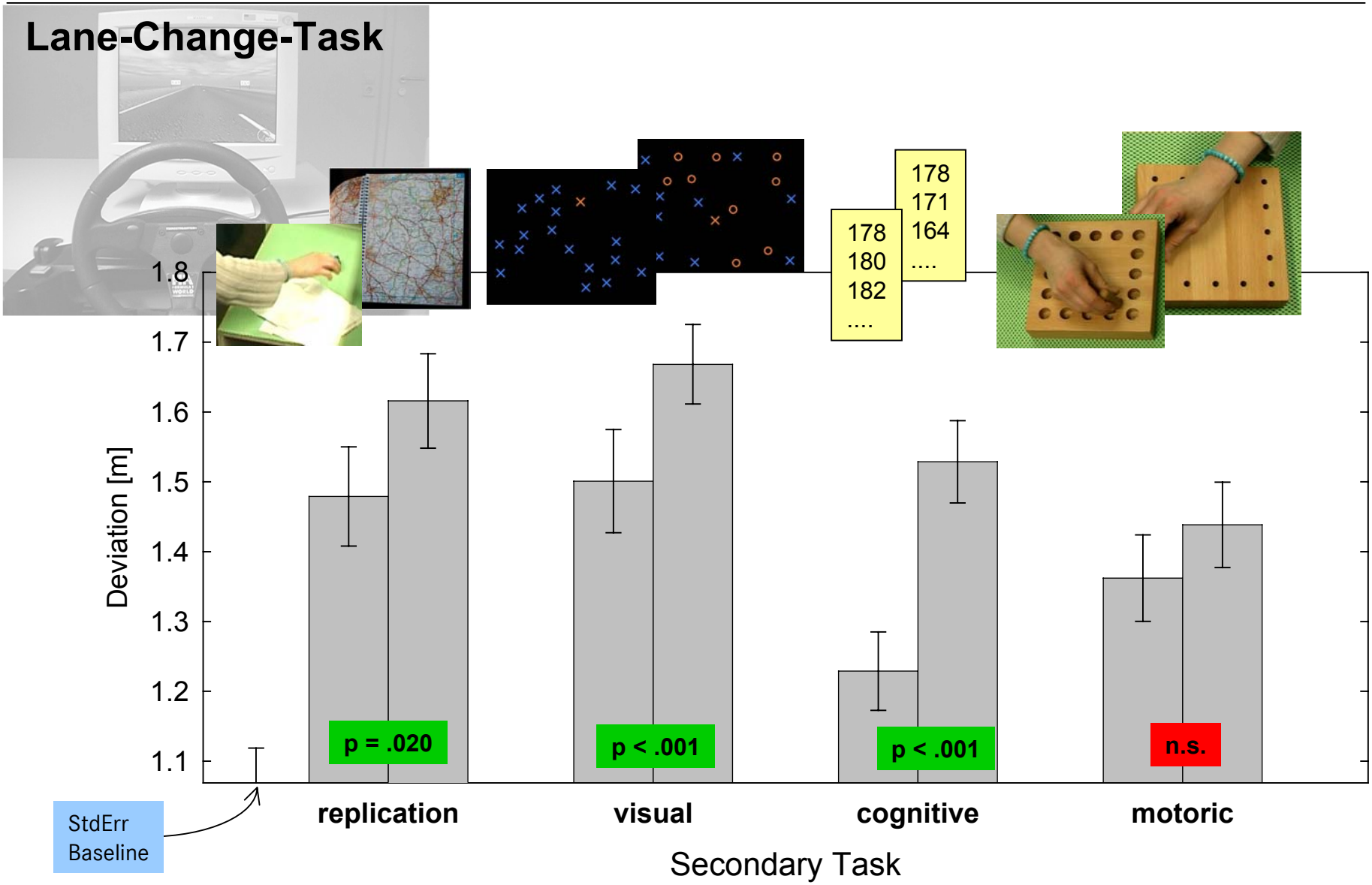


easy

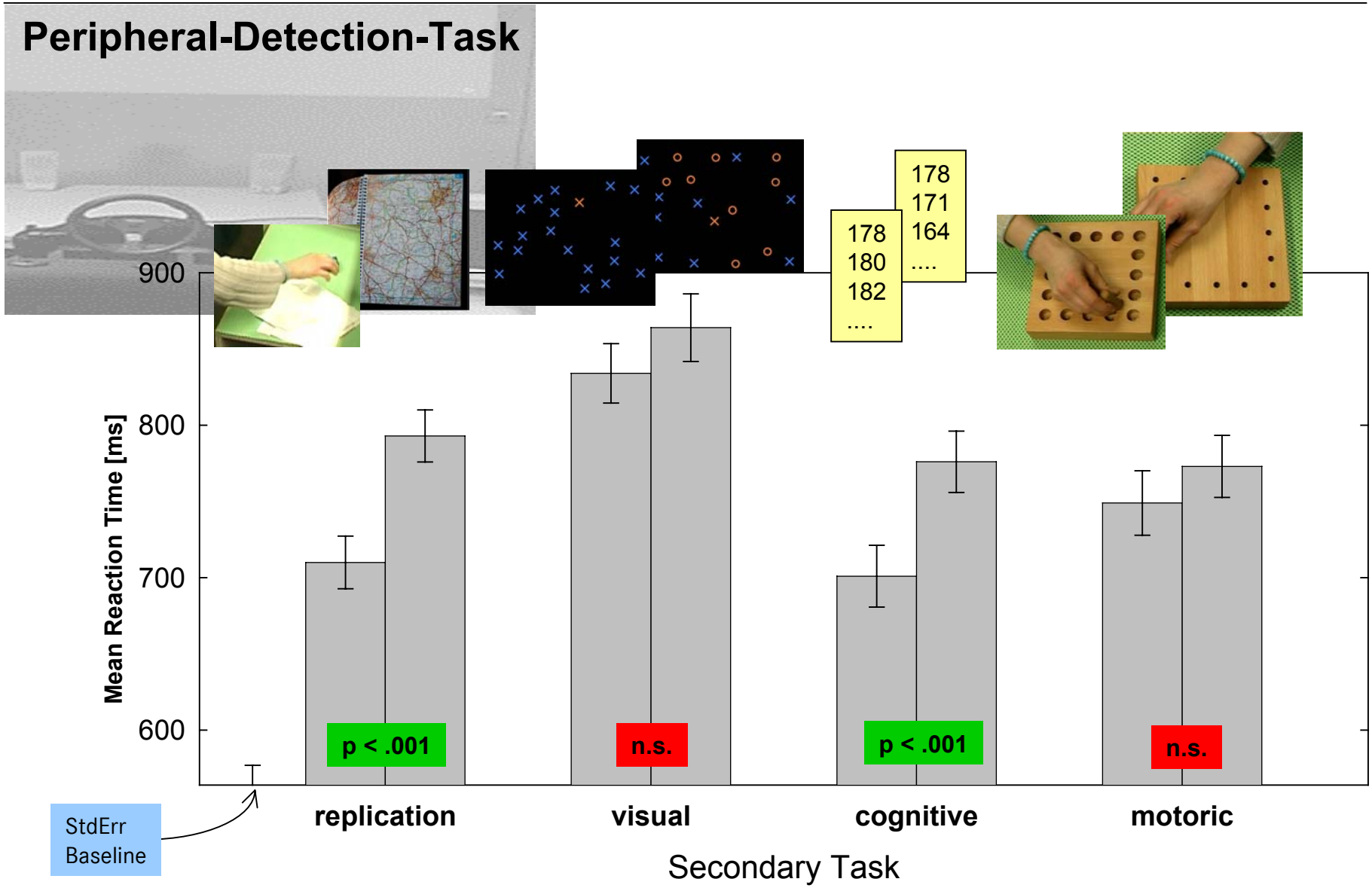


difficult

Lane Change Task

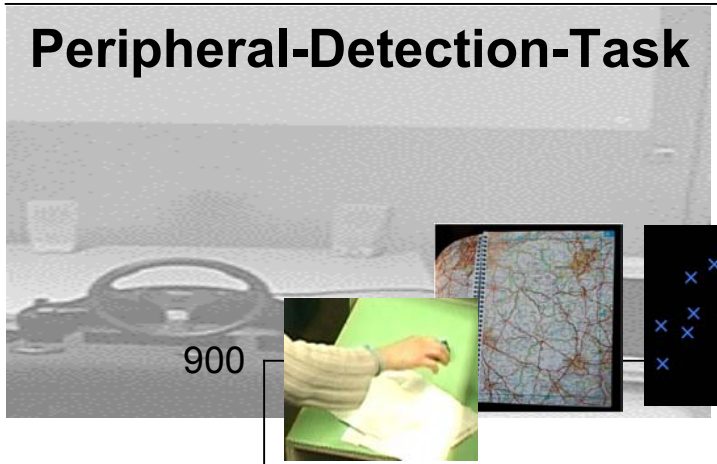


Lane Change Task



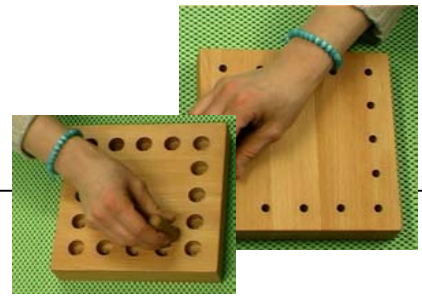
Lane Change Task

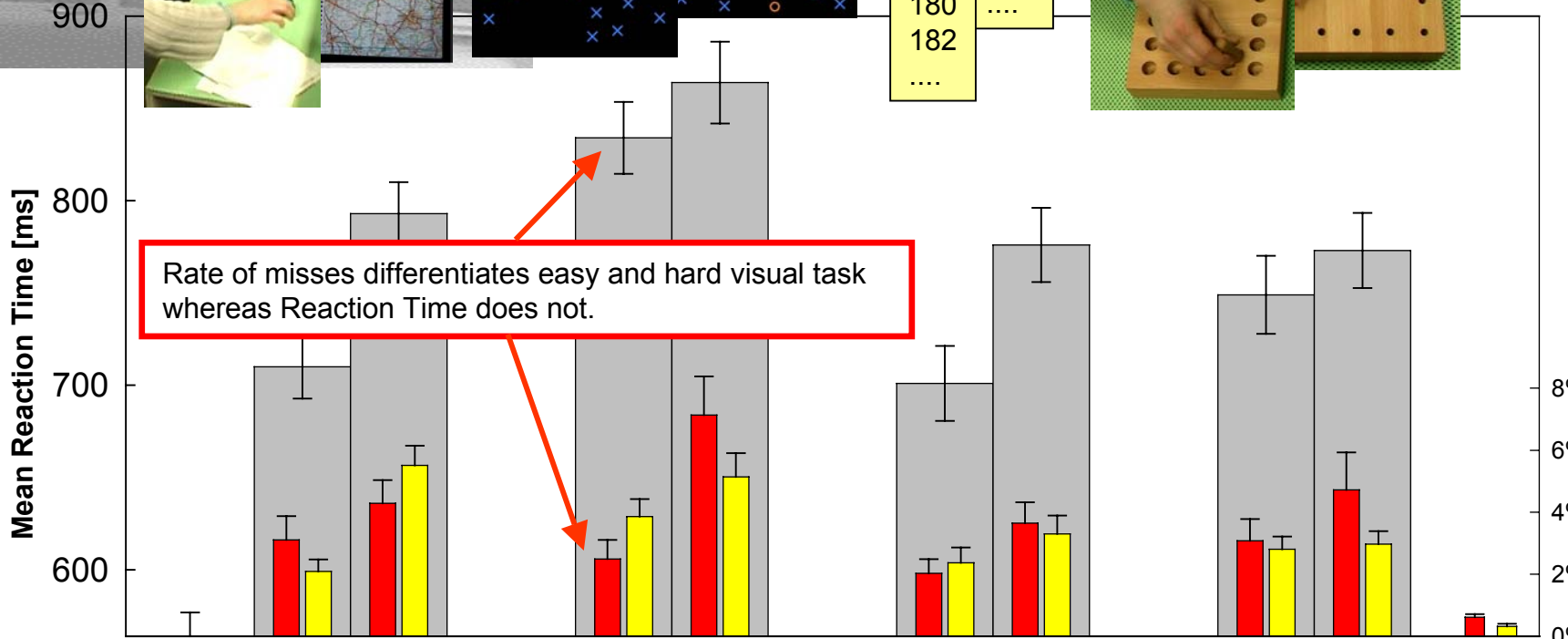
Peripheral-Detection-Task



178
171
164
....

178
180
182
....





Rate of misses differentiates easy and hard visual task whereas Reaction Time does not.

Conclusions

- LCT is a simple and efficient tool for driver distraction evaluation.
- LCT is especially sensitive to visual and cognitive distraction.
- Recommendation: prefer **continuous measurement** to **special events** approach.
- For method evaluation use secondary tasks with **logical rank order**.

Free copies of Lane Change Task simulation- and analysis software for research purposes are available upon request:
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