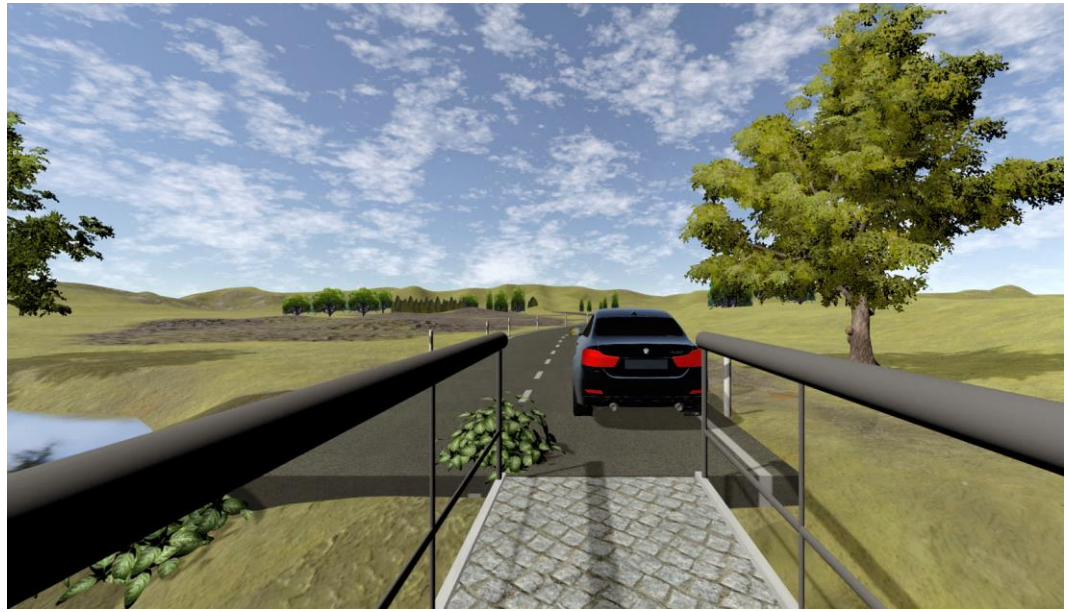
SEAMLESS USER EXPERIENCE IN DRIVING SIMULATION STUDIES



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DSC VR 2019

Universität Bremen

ISSUES

Some users do not consider driving simulators as a realistic vehicle [1]

Perception from outside the simulation environment reduces the presence [2]

PRESENCE

Sense of being in a particular place [3]

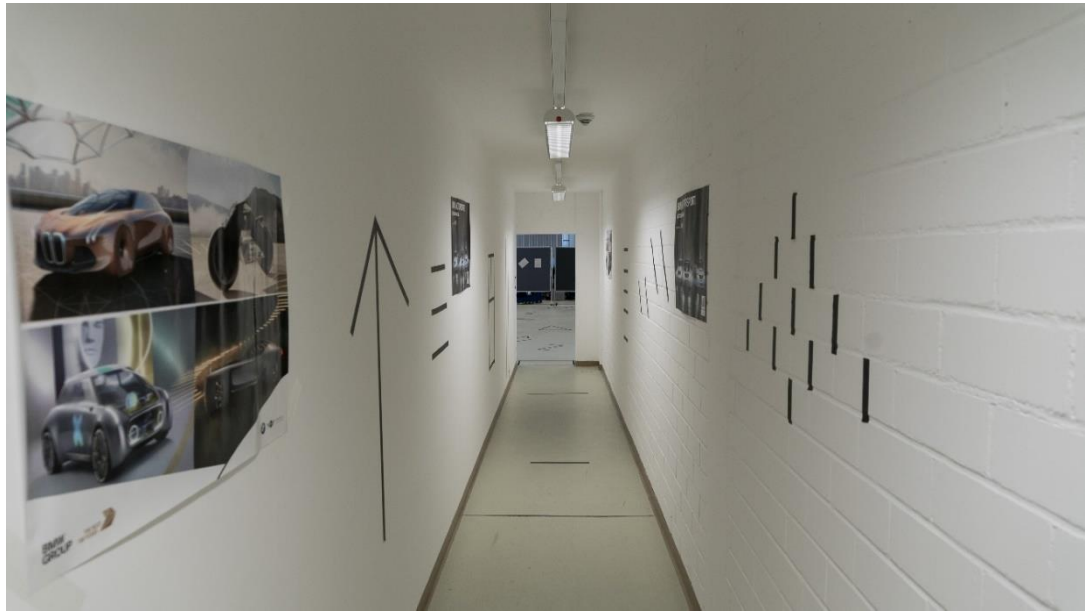
Presence = Place Illusion **(PI)** + Plausibility Illusion **(Psi)** [4]

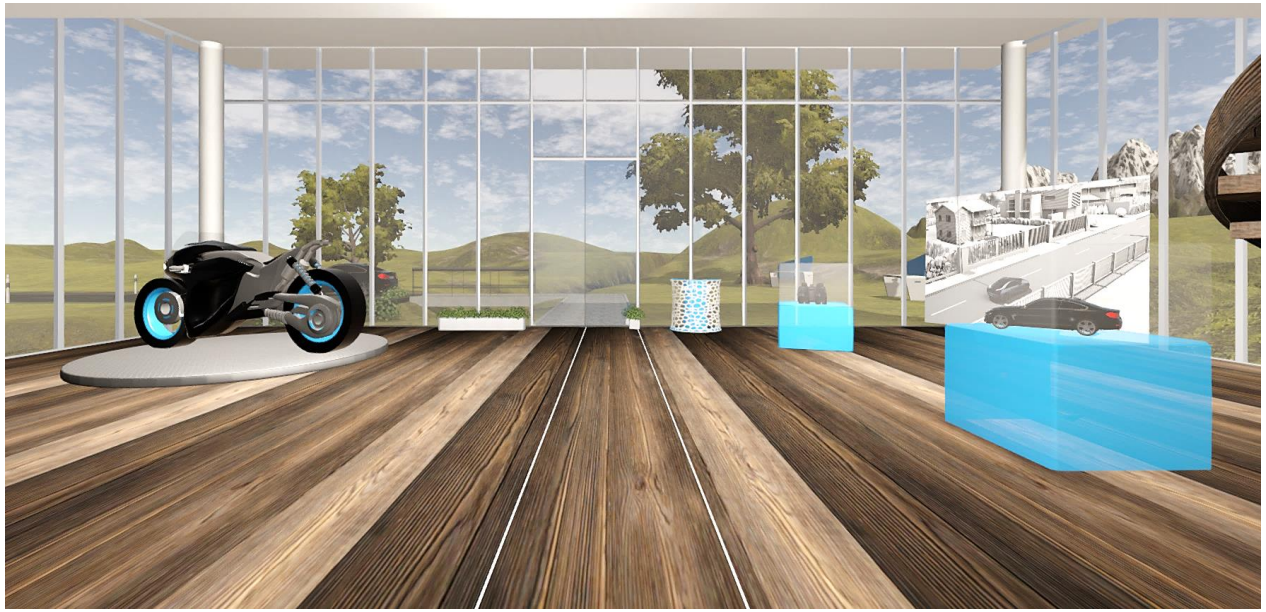
PI - illusion of location

Psi - illusion that what is happening is really happening

CONCEPT

Guiding participants to the simulator through the virtual transition environment displayed in VR HMD



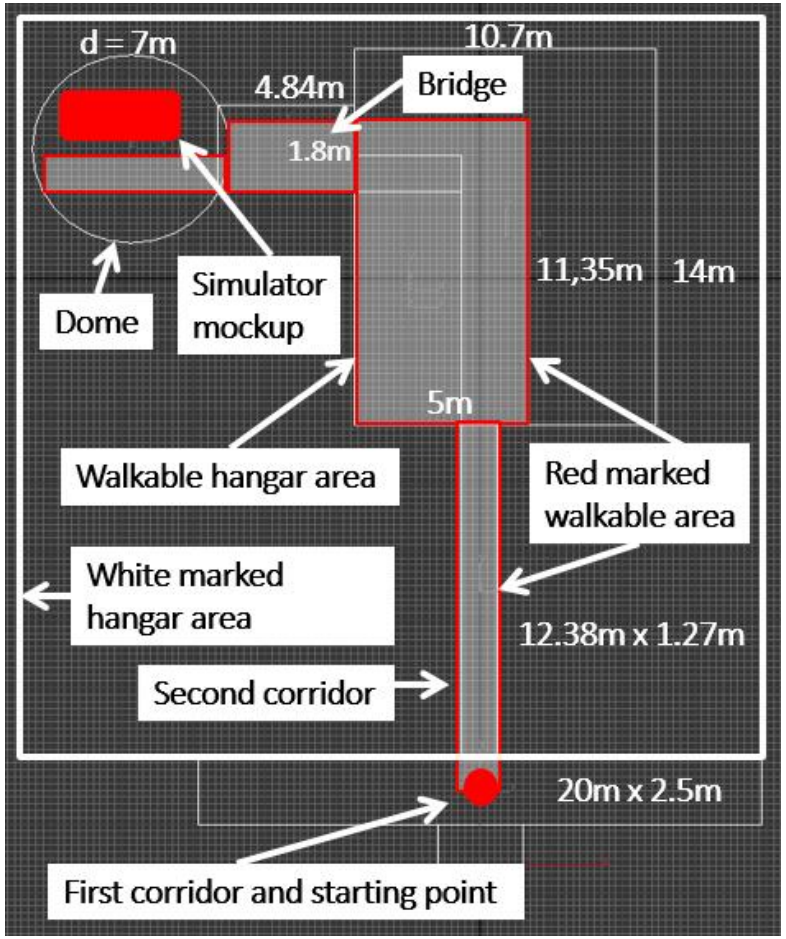


HYPOTHESIS

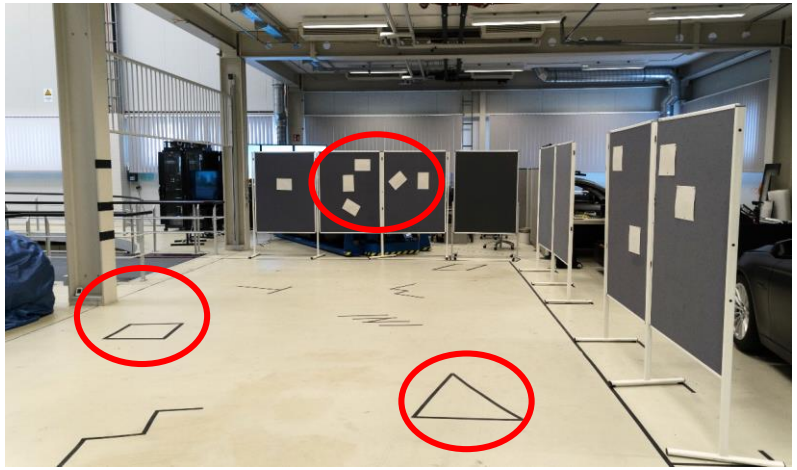
The participants exposed to the virtual transition environment have a stronger sense of presence during the driving simulation than the group that enters the simulator through the real hallways.

CHALLENGES

Real rooms plan



Inside-out tracking stabilization



TECHNICAL SOLUTION

Dell Visor Windows Mixed Reality HMD

- 90 FPS
- Inside-Out Tracking
- 1440x1440 liquid crystal displays
- 105° horizontal FOV

MSI Backpack PC VR One 7RE- 083

- Intel® Core™ i7–7820HK, 4x 2.90 GHz
- Nvidia GeForce GTX1070
- 16 GB RAM, 512 GB SSD

TECHNICAL SOLUTION

Dynamic Driving Simulator

- 6 DOF hexapod-based motion system
- 240° projection
- Vehicle mock-up placed in the dome

EXPERIMENT DESIGN

Between-subjects design: comparison VR group vs. Not VR group

Subjective measurements:

- Self-report questionnaires *(PED, SSQ, IPQ, SUS)*
- Immediate feedback assessment *(presence question, criticality question)*

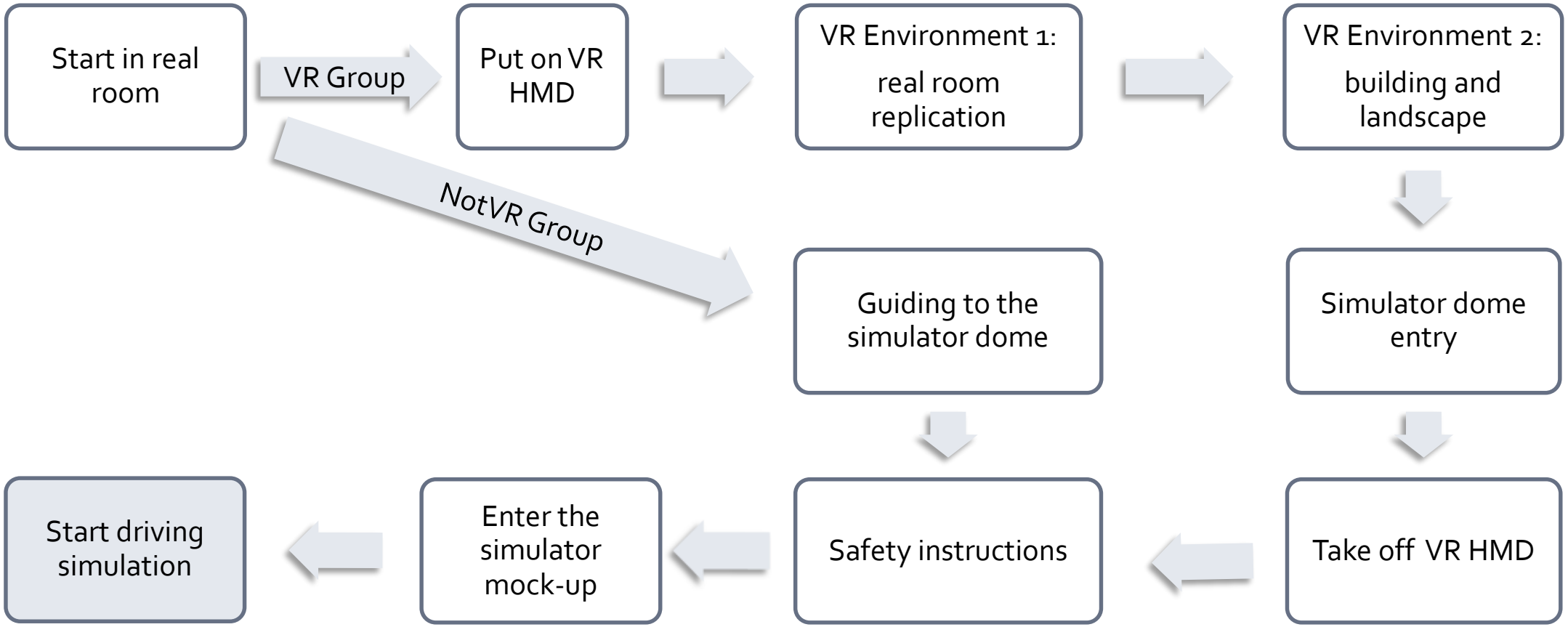
Objective measurements:

- Driving behaviour *(velocity, brake, lane offset)*
- Physiological data *(heart rate, skin conductance)*

Explorative measurements:

- Behaviour observation *(call response)*
- Creative tasks *(only VR group)*

EXPERIMENT PROCEDURE



Master Thesis Project

„Seamless User Experience in Driving Simulation Studies."

by Victoria Ivleva

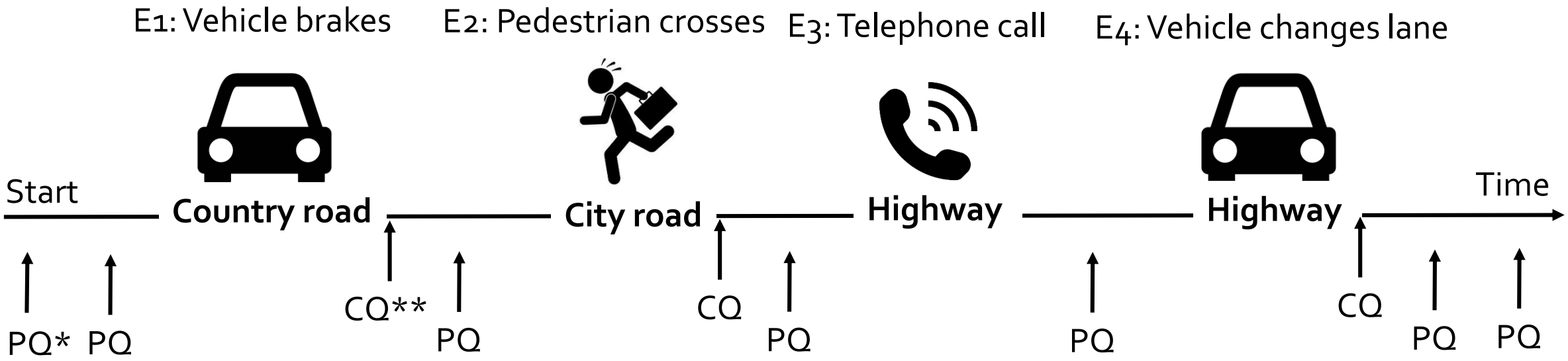
Supervisors:
Prof. Dr. Gabriel Zachmann, University of Bremen
Sergej Holzmann, BMW AG

Cooperation BMW AG Driving Simulation Center with University of Bremen Digital Media department

12.2017-06.2018 München

DRIVING SIMULATION SCENARIO

4 critical events, 3 road types, 2 questions

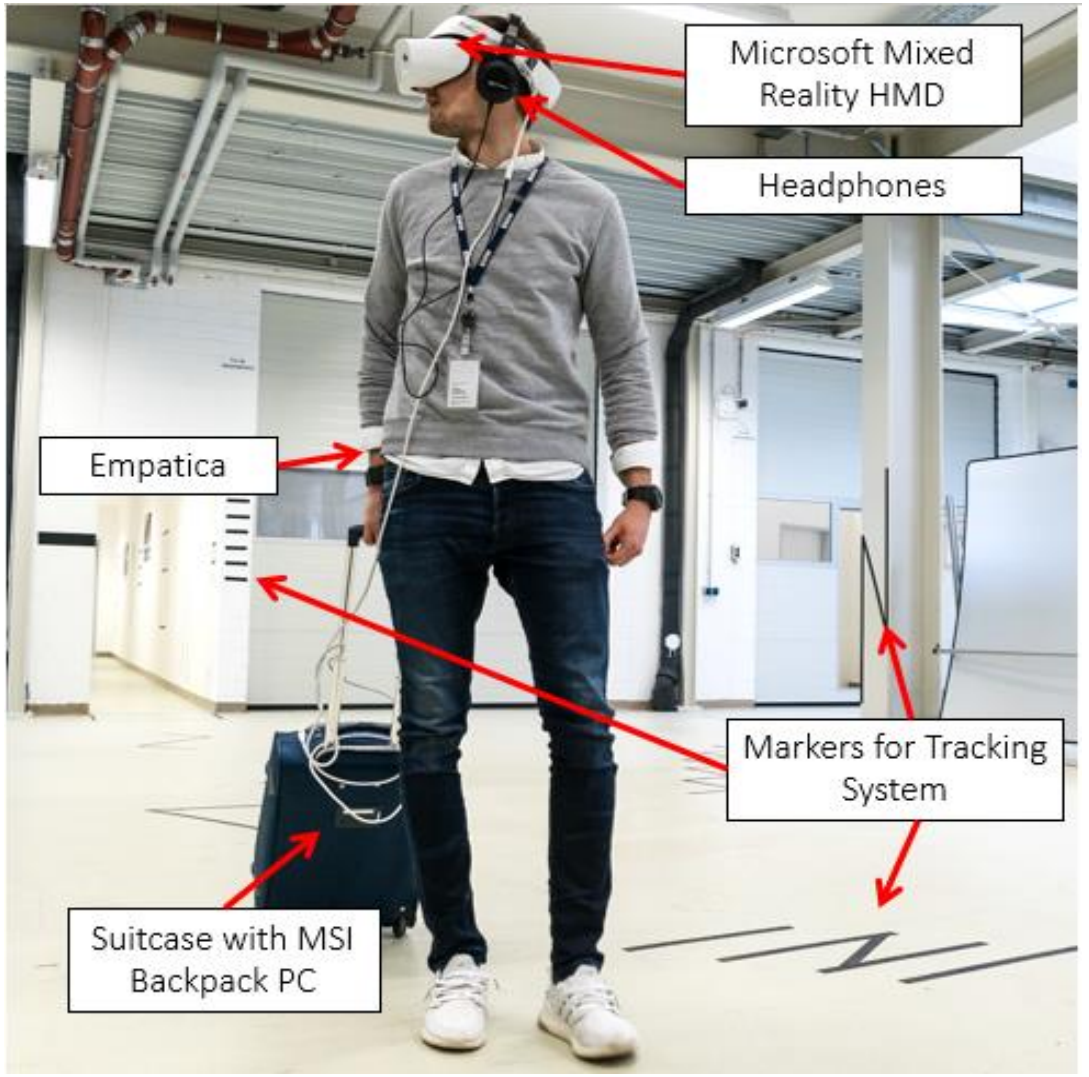


*Presence question: *„ Please rate your presence on a scale of 1 to 10"*

**Criticality question: *„How critical was the situation, please rate from 1 to 3"*

USER STUDY PARTICIPANTS

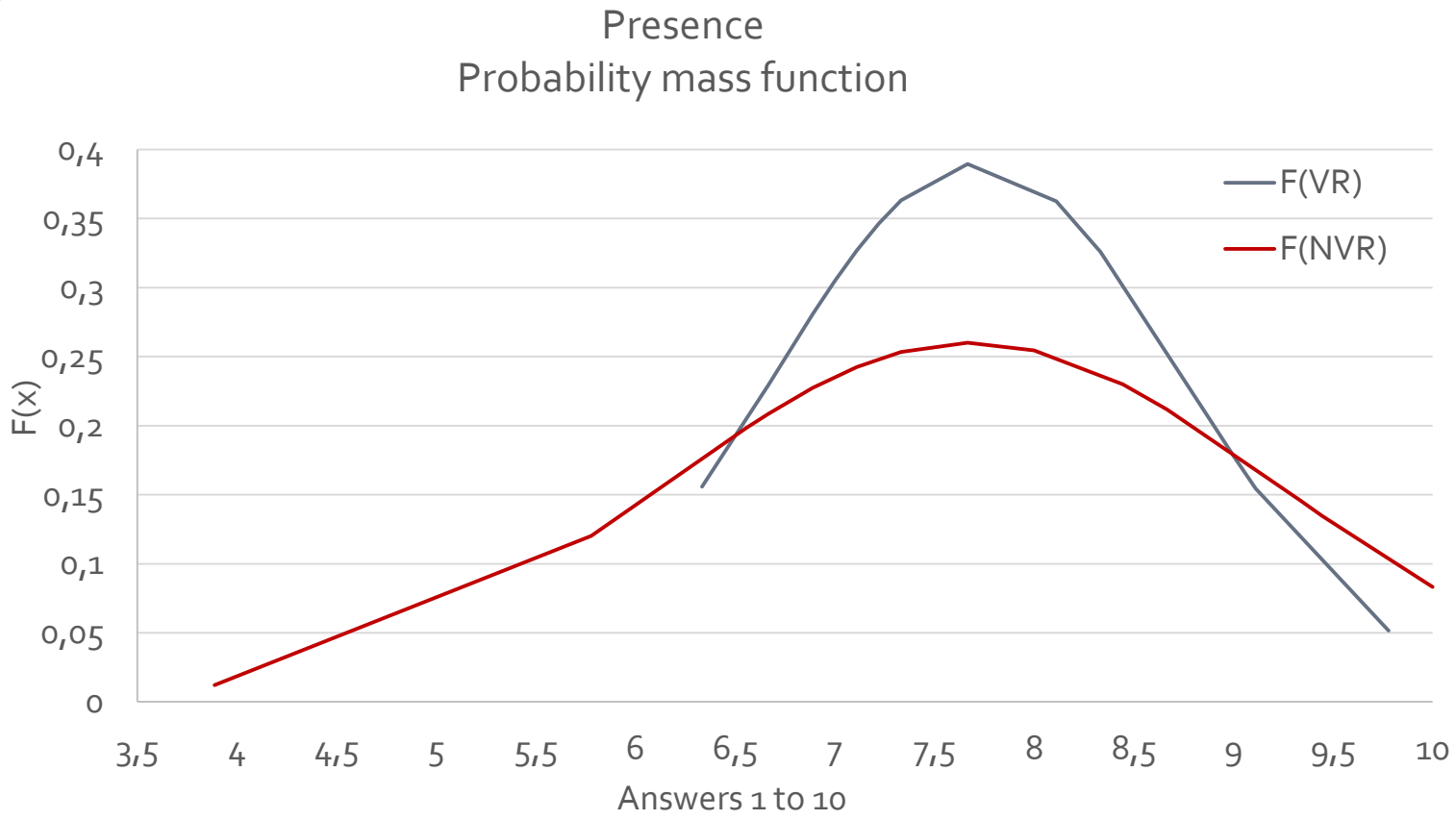
- 41 participants
- 19 participants in each group
- 3 participants aborted participation
- 68% man, 32% woman, 23-60 y.o.
- 80% have VR experience
- 54% have driving simulation experience
- 12 years average driving experience
- 49% engineers, 20% IT specialists



RESULTS: IMMEDIATE FEEDBACK ASSESSMENT

Sense of Presence while driving

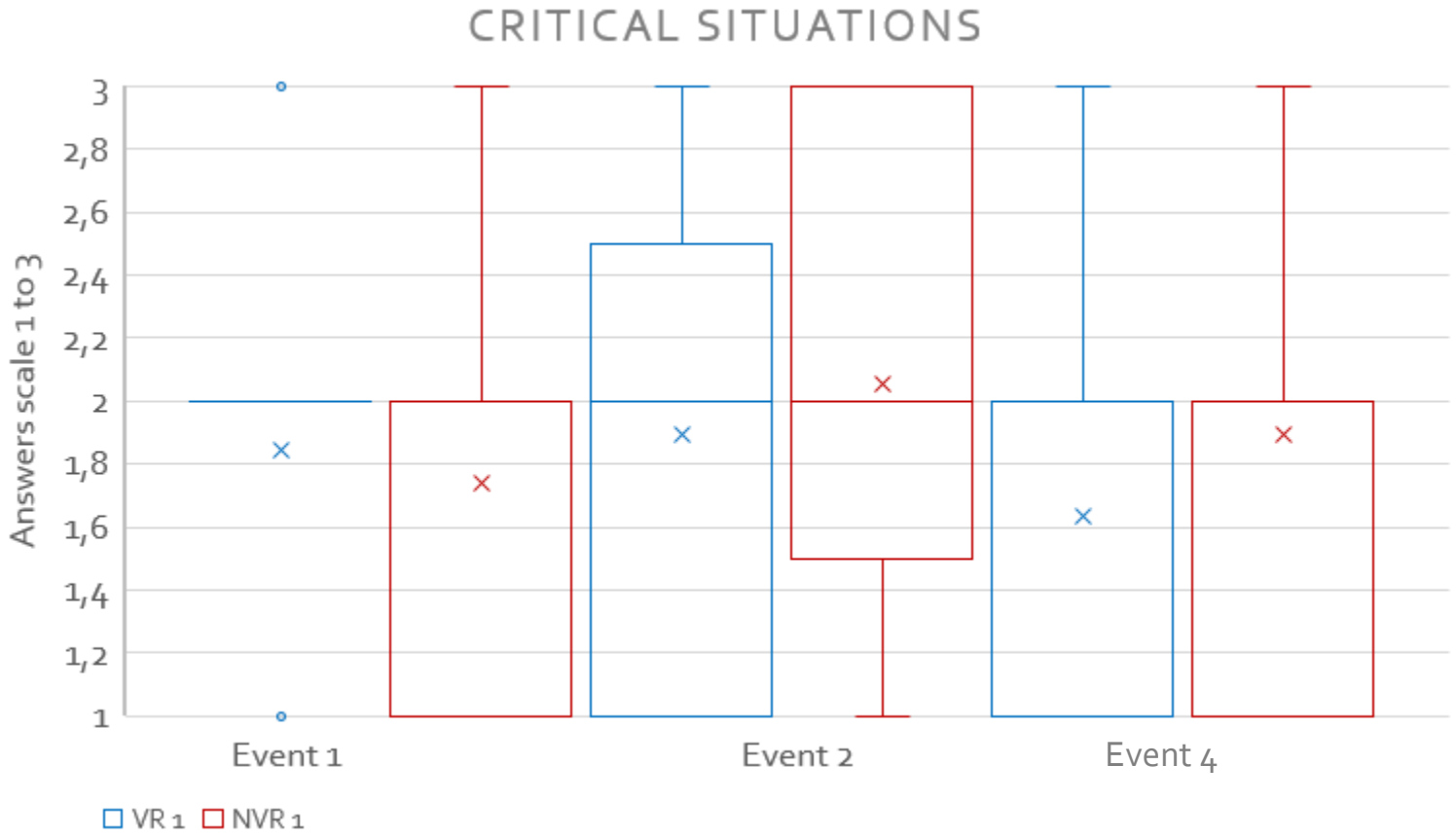
- Single-question
- Repeated 9 times
- Answer scale 1 to 10



RESULTS: IMMEDIATE FEEDBACK ASSESSMENT

Critical situations while driving

- 3 events
- Single-question
- Answer scale 1 to 3



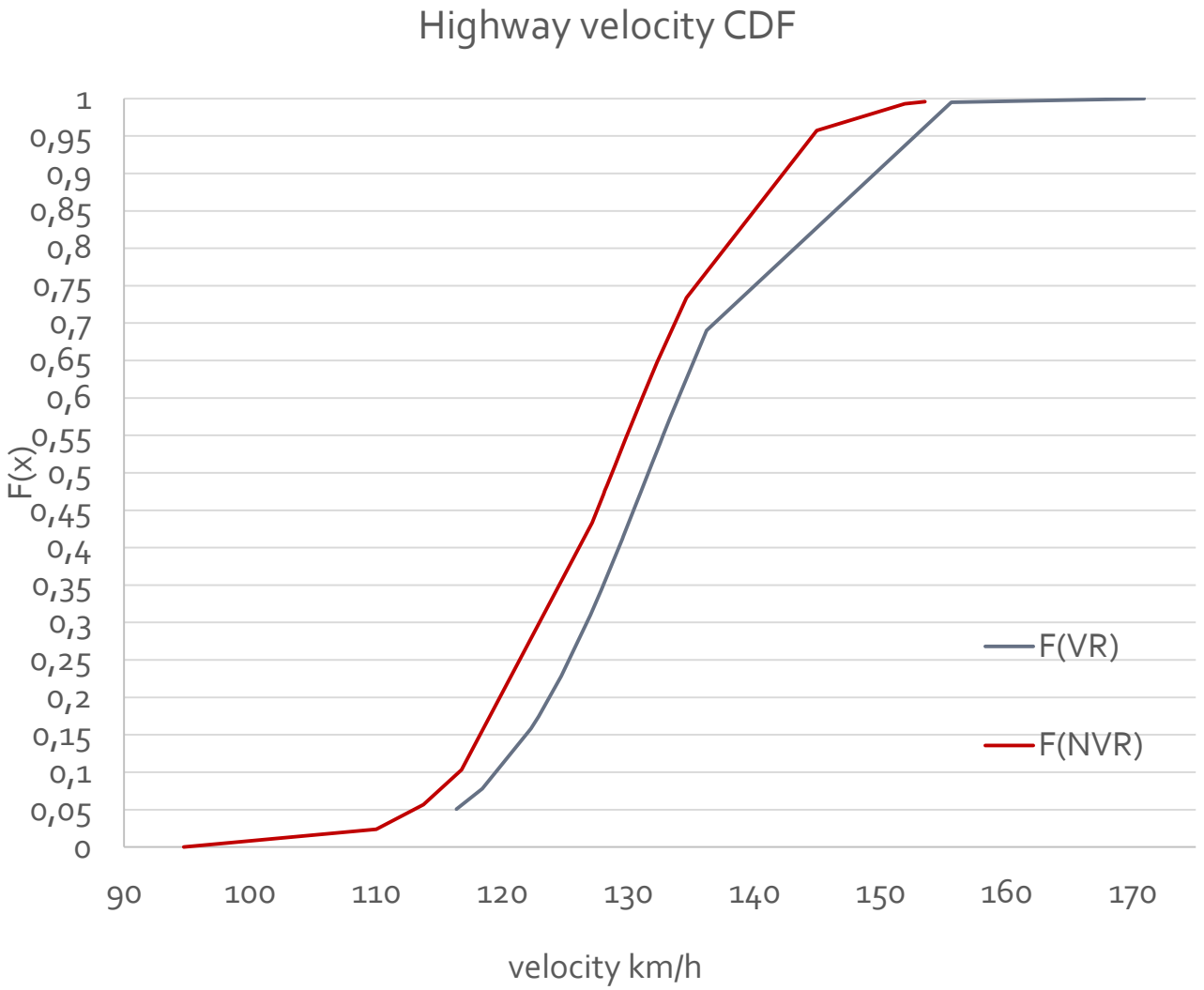
RESULTS: DRIVING BEHAVIOUR

Driving velocity

- Country road – no significant difference
- City road- no significant difference
- Highway VR > NVR (3 km/h)

Self-estimation velocity

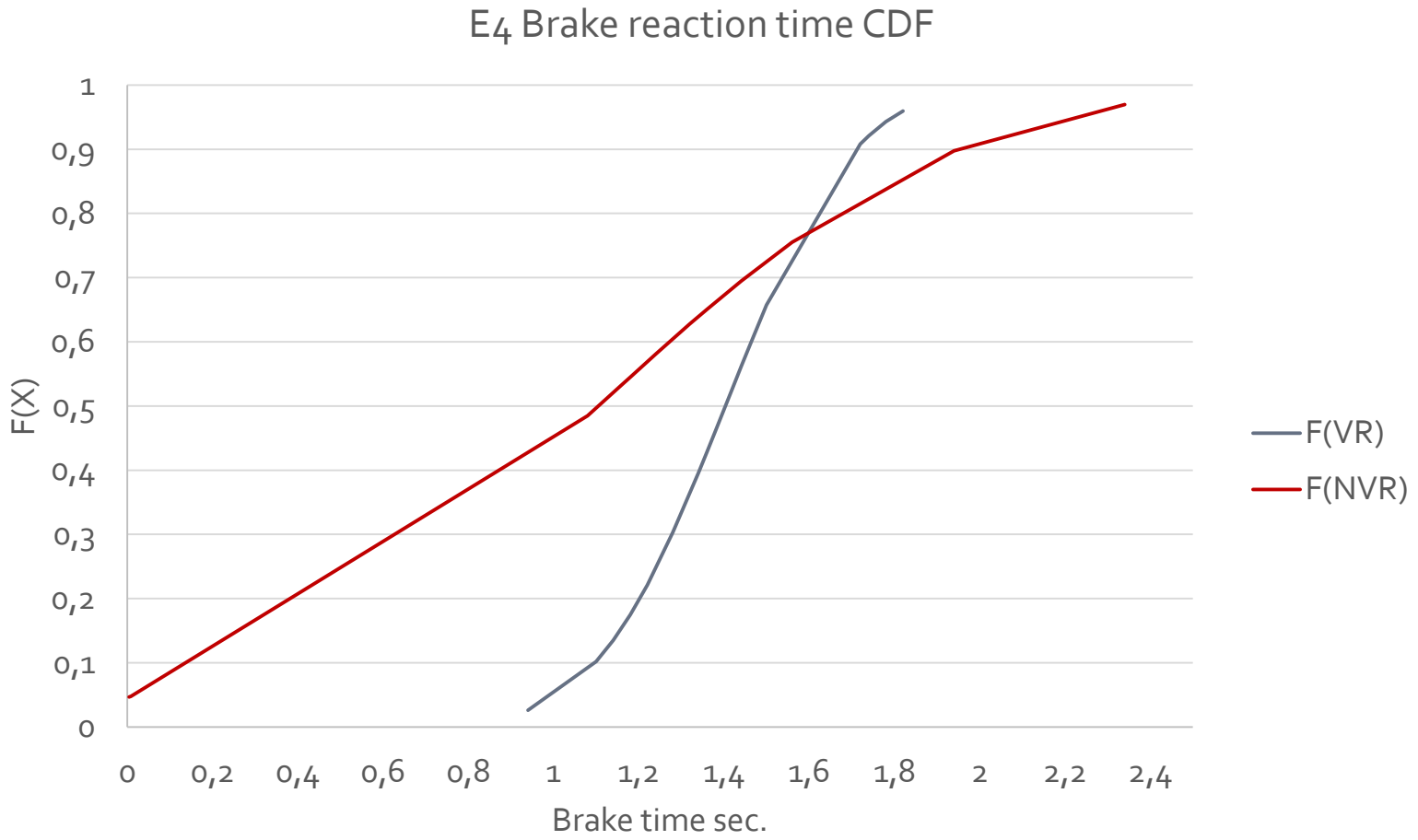
- Real world driving velocity > simulator
- Especially on the highway (max. 27 km/h)



RESULTS: DRIVING BEHAVIOUR

Brake reaction time $br = tb - ts$

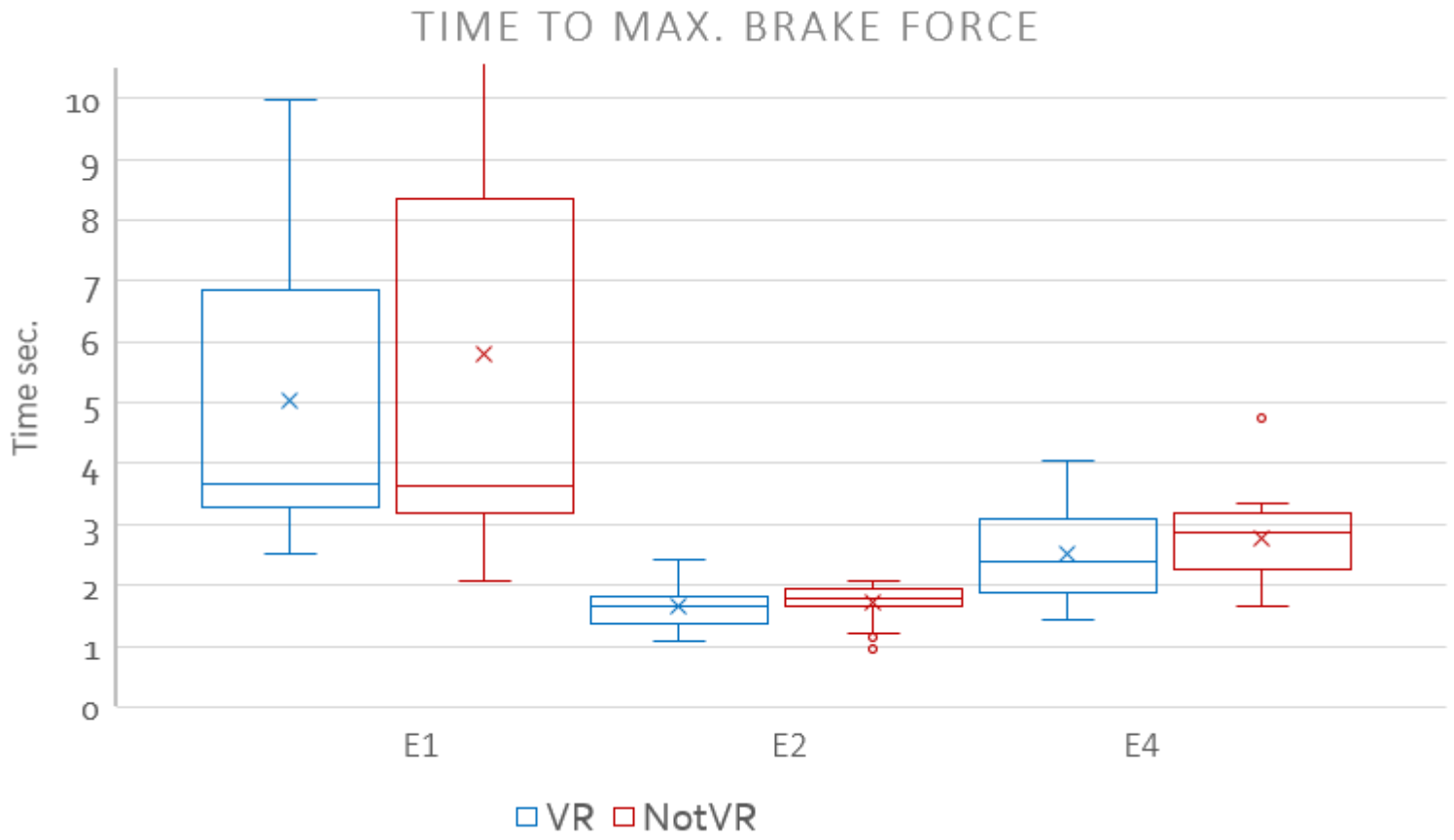
- E1 VR > NotVR 0.5 sec.
- E2 VR < NotVR 0.4 sec.
- E4 VR > NotVR 0.9 sec.



RESULTS: DRIVING BEHAVIOUR

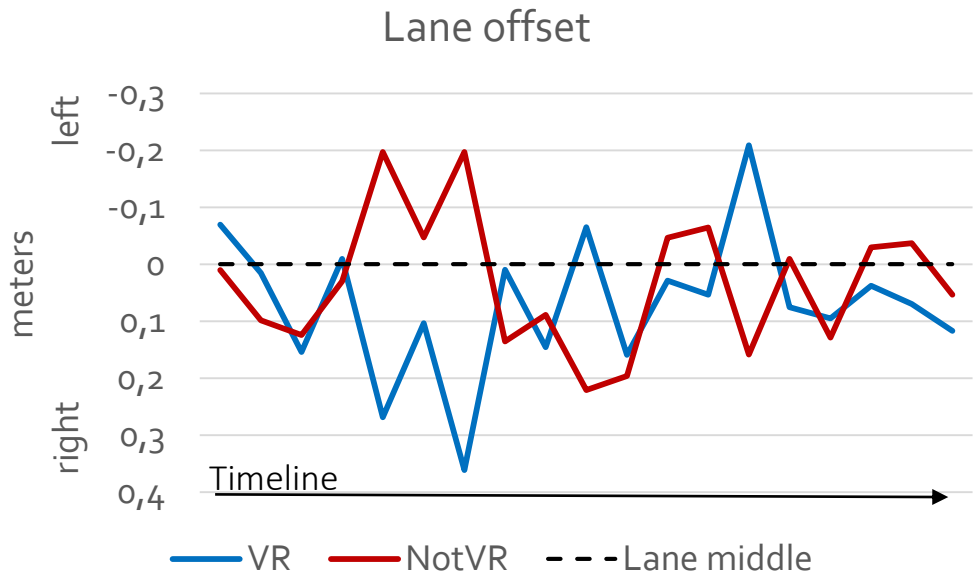
Brake reaction time to max force

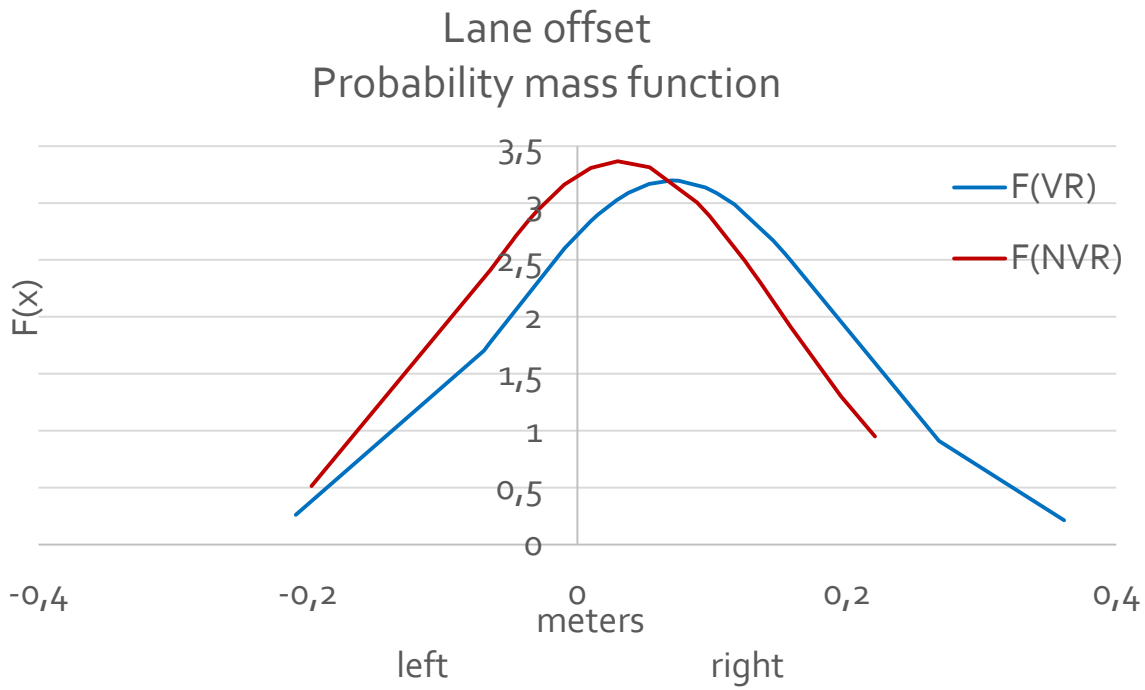
- E1 VR < NotVR
- E2 VR < NotVR
- E4 VR < NotVR



RESULTS: DRIVING BEHAVIOUR

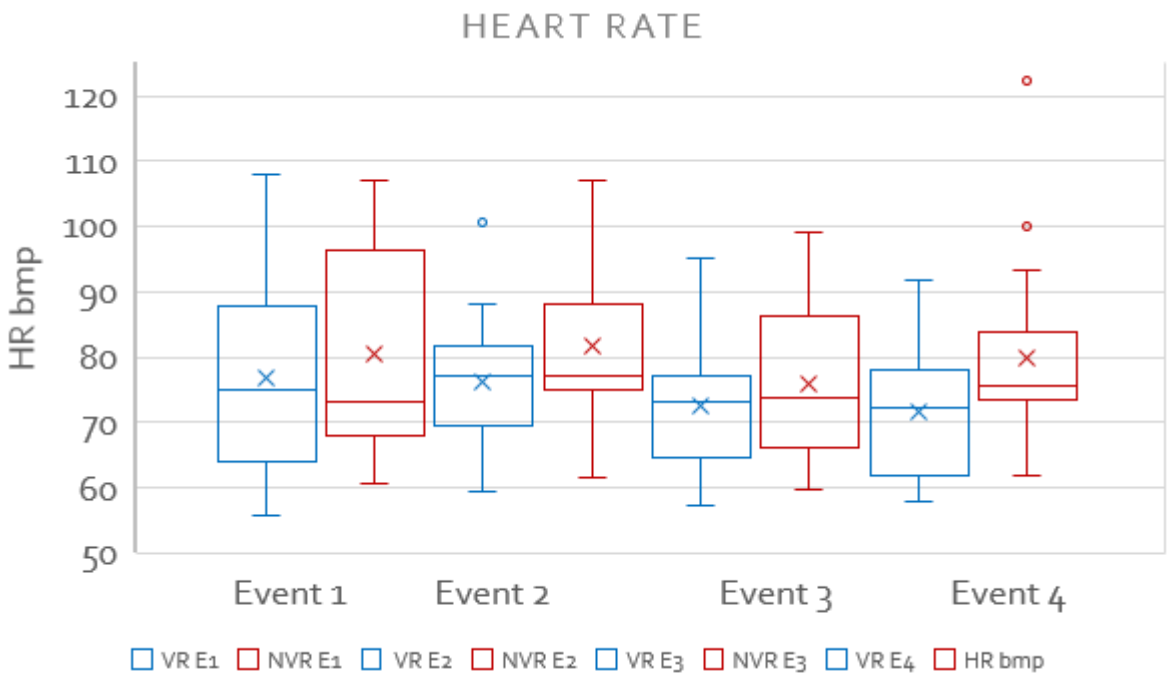
Lane offset $$m = \frac{r + l}{2} - r$$



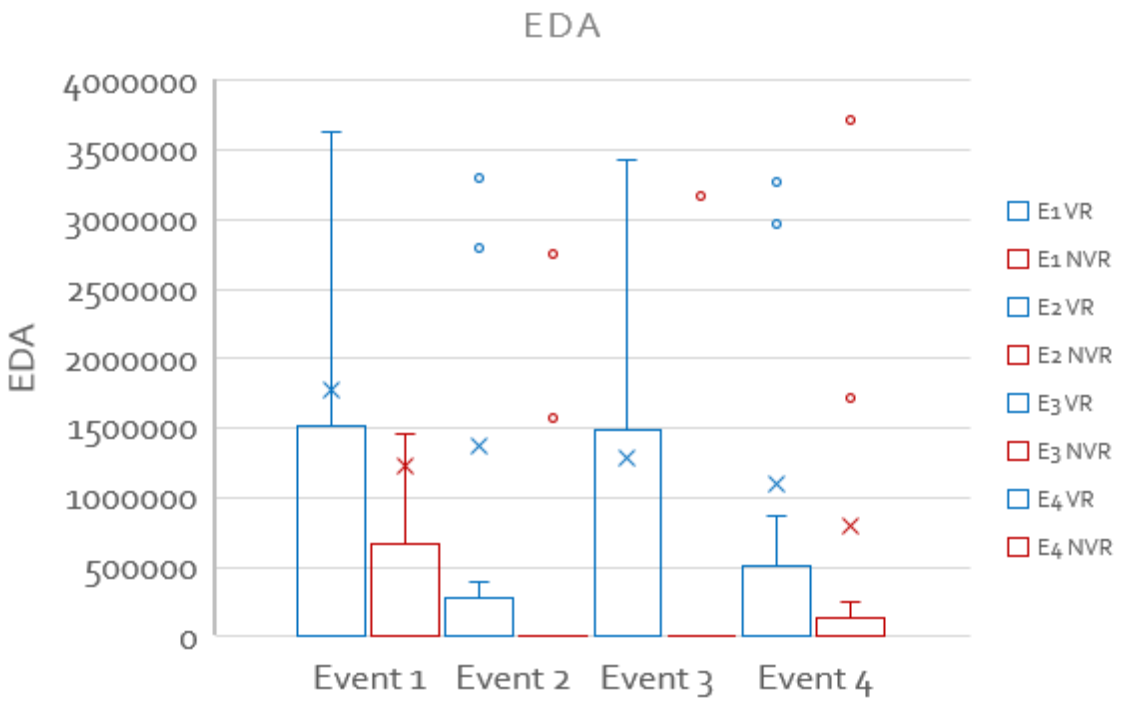


RESULTS: PHYSIOLOGICAL DATA

Heart rate *(beats per minute)*

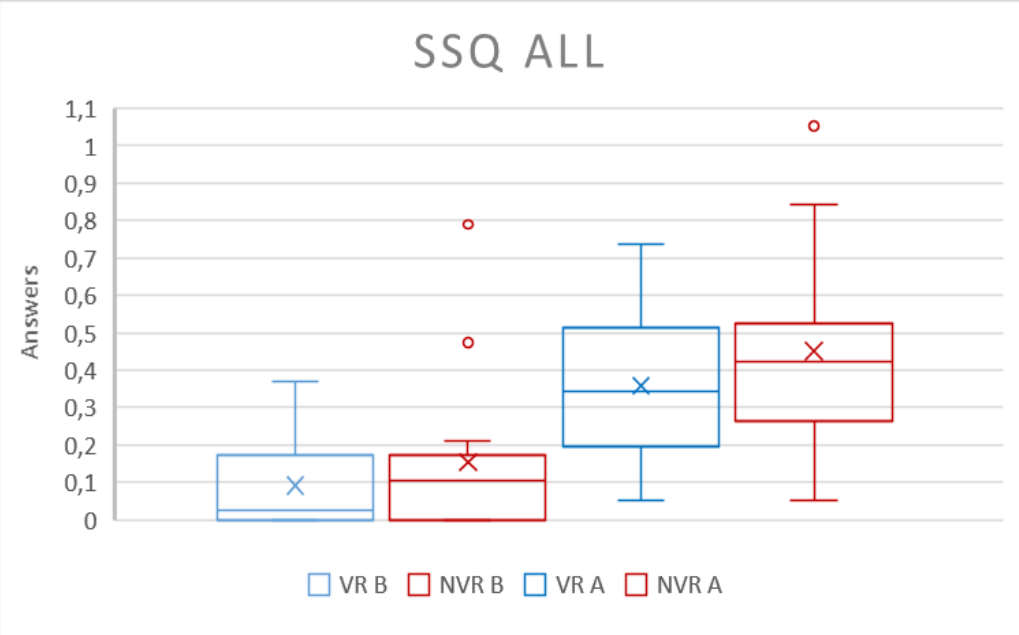


Skin conductance *(micro-Siemens µS)*



RESULTS: SUBJECTIVE DATA

Motion Sickness Questionnaire



Igroup Presence Questionnaire

- Spatial Presence: no significant difference
- Involvement: no significant difference
- Realness perception: VR > NotVR

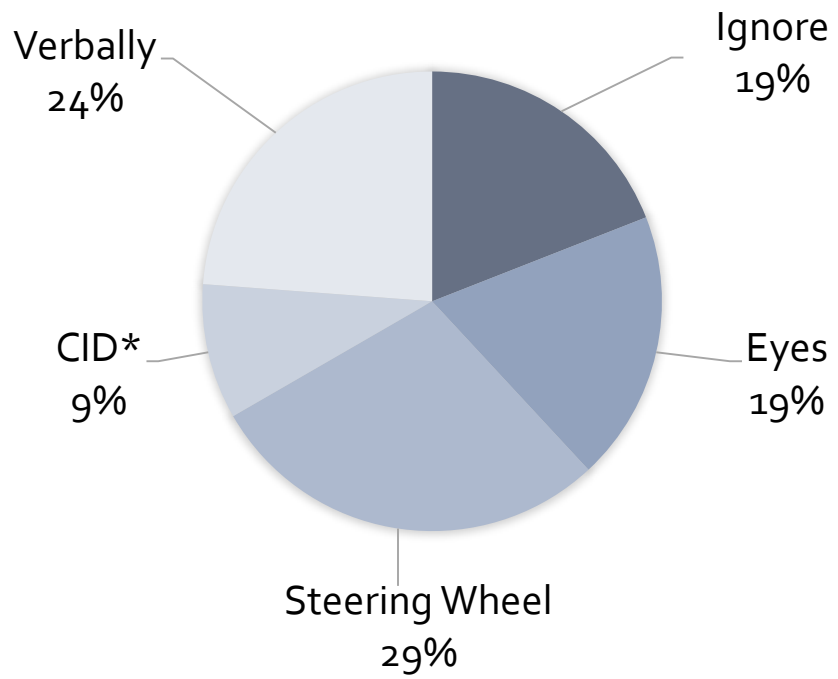
Slater-Usoh-Steed presence questionnaire

- Overall score of high responses *(max 49)*
  - VR 30 > NotVR 25

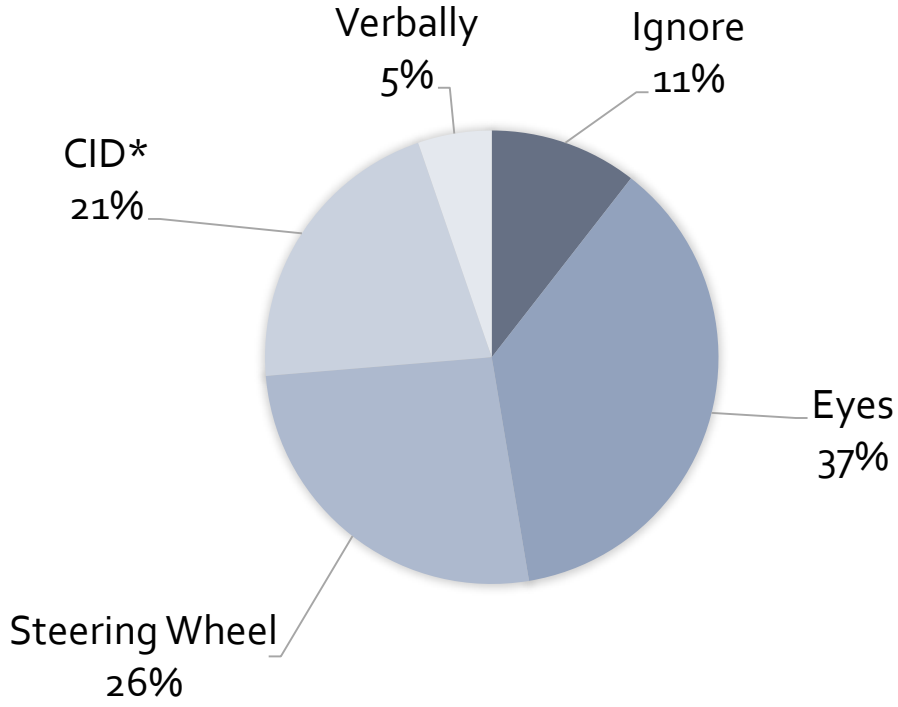
EXPLORATIVE RESULTS: BEHAVIOUR OBSERVATION

Phone call response

- VR Group



- NotVR Group



**Central Information Display*

EXPLORATIVE RESULTS: CREATIVE TASK

- Realistisch - realistic
- Zukunft - future
- Einladend - inviting
- Schön - beautiful
- Sauber - clean
- Angenehm - enjoyable
- Freundlcih - friendly
- Künstlich - synthetic
- Einsam - lonely
- Leer - empty
- Sauber - clean

CONCLUSION: FINDINGS

Driving behaviour and immediate self-assessment feedback

- No significant difference between VR and Not VR groups

Physiological data

- Not significantly different between the groups, NotVR group had higher heart rate

Questionnaires IPQ, SUS

- VR group reported significantly higher realness perception and sense of presence
- No significant difference in spatial perception and involvement (attention)

Explorative data

- VR Transition had an impact on users' perception and behaviour

FUTURE DIRECTIONS

Take off the VR HMD inside of the simulator mock-up

Increase the time in the VR

More interactions and tasks in VR

- Preliminary conversation and safety instructions also in VR
- Pick up the car keys at the information desk
- Interact with human avatars

Explore other aspects: e.g. distance estimation

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THANK YOU FOR YOUR ATTENTION!

ANY QUESTIONS?