DSC 2023 EUROPE VR

Driving Simulation & Virtual Reality Conference & Exhibition

Effects of visualization quality on the sense of presence in a pedestrian simulator

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Antibes

September 6th – 8th 2023

Introduction

- Mobility is an important topic that moves people both figuratively and literally
- It is being intensively researched and that is why road traffic has become increasingly safer over the past decades
- Being a pedestrian is still the riskiest way to get around
- Rising scientific interest in Vulnerable Road Users (VRU)

Introduction

- The most interesting considerations are often the most dangerous ones
- Simulators are important scientific tools for save and cost efficient human centered research
- Remodeling of an existing laboratory to enable VRU research in 2021
  - Focus on interaction

Introduction

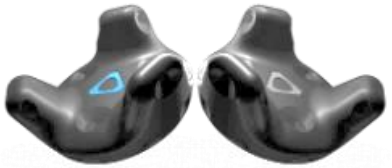
- ~50% of all crashes in urban areas take place at or nearby intersections
- Intersections can be very complex and hard to solve for all road users
- Various interactions take place between pedestrians, cyclists and motorised vehicles

Source:: acatech

Recap DSC 2022

Lab presentation by Martin Fischer

VR Controller



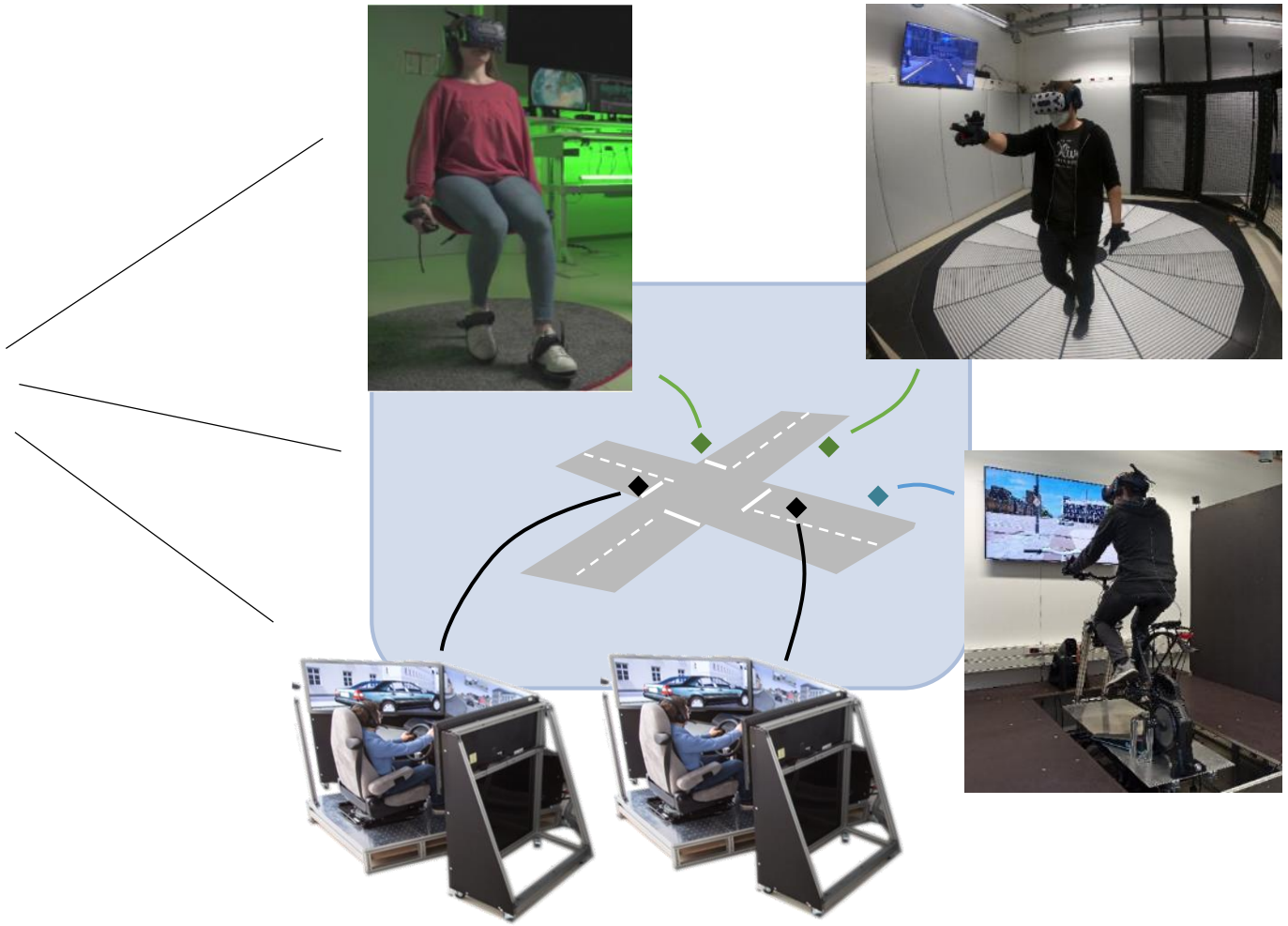
VR Tracker

Manus VR gloves

Recap DSC 2022

Lab presentation by Martin Fischer

MoSAIC VRU Lab control station



Introduction

- Evaluation of the visual representation in **pedestrian simulation** with the goal to provoke natural user behavior
- **Focus on Presence, Task Mastery and Simulator Sickness**

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in the context of visual realism

- Are past findings applicable to the new simulation environment?
  - Less performant hardware
  - Focus on motorized vehicles

Research Question

In the context of pedestrian simulation…

Is it necessary to design highly realistic virtual environments to provoke natural user behavior?

Research Question

In the context of pedestrian simulation…

Is it necessary to design highly realistic virtual environments to provoke natural user behavior?

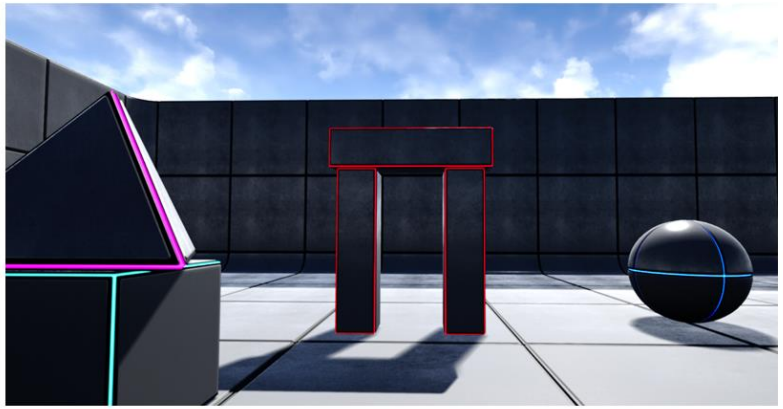
How does the visualization quality influences the feeling of presence?

Experimental Design - Simulator

- Pedestrian simulator
  - Omnidirectional treadmill (4,7 m ⌀)
    - 16 motorized roll segments
  - HTC VIVE Pro Eye (wireless)
    - 2x 3.5" OLED screens
    - 90 Hz refresh rate
  - 2x Valve Index Controller
  - Steam VR
  - Unreal Engine 4

Experimental Design - Training

- 15 minute training before main experiment
  - 2 test environments with increasing difficulty
- Test subject becomes familiar with the simulator



Experimental Design - Scenarios

Virtual test environment

low

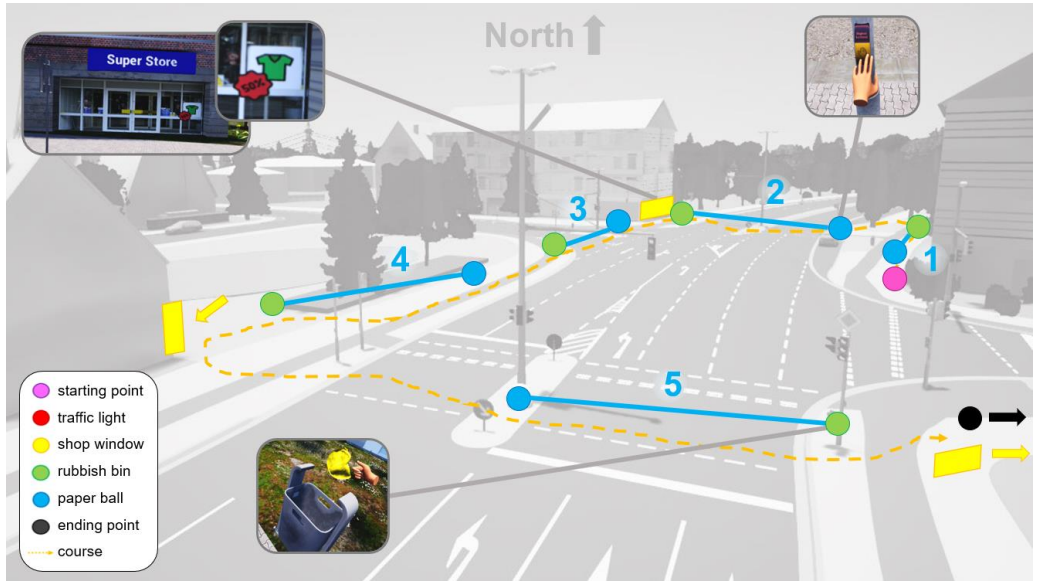
medium

high

- Variation in textures, sky and object density
- No variation in task related objects, sound or graphic settings

Experimental Design - Tasks

- Safely crossing the street
- Interacting with traffic lights
- Picking up paper balls
- Correct disposal of paper balls
- Recognizing and naming the contents of shop windows



→ Distract the subject from its own locomotion
→ Promote presence
→ Measure task mastery

Experimental Design – Subjectiv Measures and Sample

- Within subject design study with 30 Participants
- Dependant variables:
  - Presence
  - Simulator Sickness
  - Performance/Task mastery

Experimental Design – Subjectiv Measures and Sample

- Within subject design study with 30 Participants

- Dependant variables:
  - Presence → Presence Questionnaire (PQ)
  - Simulator Sickness → Misery Scale Score (MISC)
  - Performance/Task mastery → Time

Experimental Design – Procedure

1. Welcome and introduction to the topic and the simulators
2. Training
3. Experiment with all conditions in balanced order
    1. Presence Questionnaire
    2. Simulation Sickness Questionnaire
    3. Misery Scale Score
4. Debriefing

Proband	Trial 1	Trial 2	Trial 3
1	low	medium	high
2	low	high	medium
3	medium	high	low

...

34	low	high	medium
35	medium	high	low
36	medium	low	high

Results

- Bayesian method for data analyse

Table 3
Evidence categories for the Bayes Factor [6]

Bayes Factor BF_{10}	Label
>100	Extreme evidence for H_1
30–100	Very strong evidence for H_1
10–30	Strong evidence for H_1
3–10	Moderate evidence for H_1
1–3	Anecdotal evidence for H_1
1	No evidence
1/3–1	Anecdotal evidence for H_0
1/10–1/3	Moderate evidence for H_0
1/30–1/10	Strong evidence for H_0
1/100–1/30	Very strong evidence for H_0
< 1/100	Extreme evidence for H_0

BF = Bayes factor.

Data suggest effect

Data suggest **no** effect

Nuzzo, R. L. (2017). An Introduction to Bayesian Data Analysis for Correlations. *PM & R : The Journal of Injury, Function, and Rehabilitation*, *9*(12), 1278–1282. https://doi.org/10.1016/j.pmrj.2017.11.003

Results - Presence

Effect of realism on the sense of presence

- The Data suggests extreme evidence in favour of the H1 (effect)

Table 7: Bayesian model comparison of the PQ rating for *realism*.

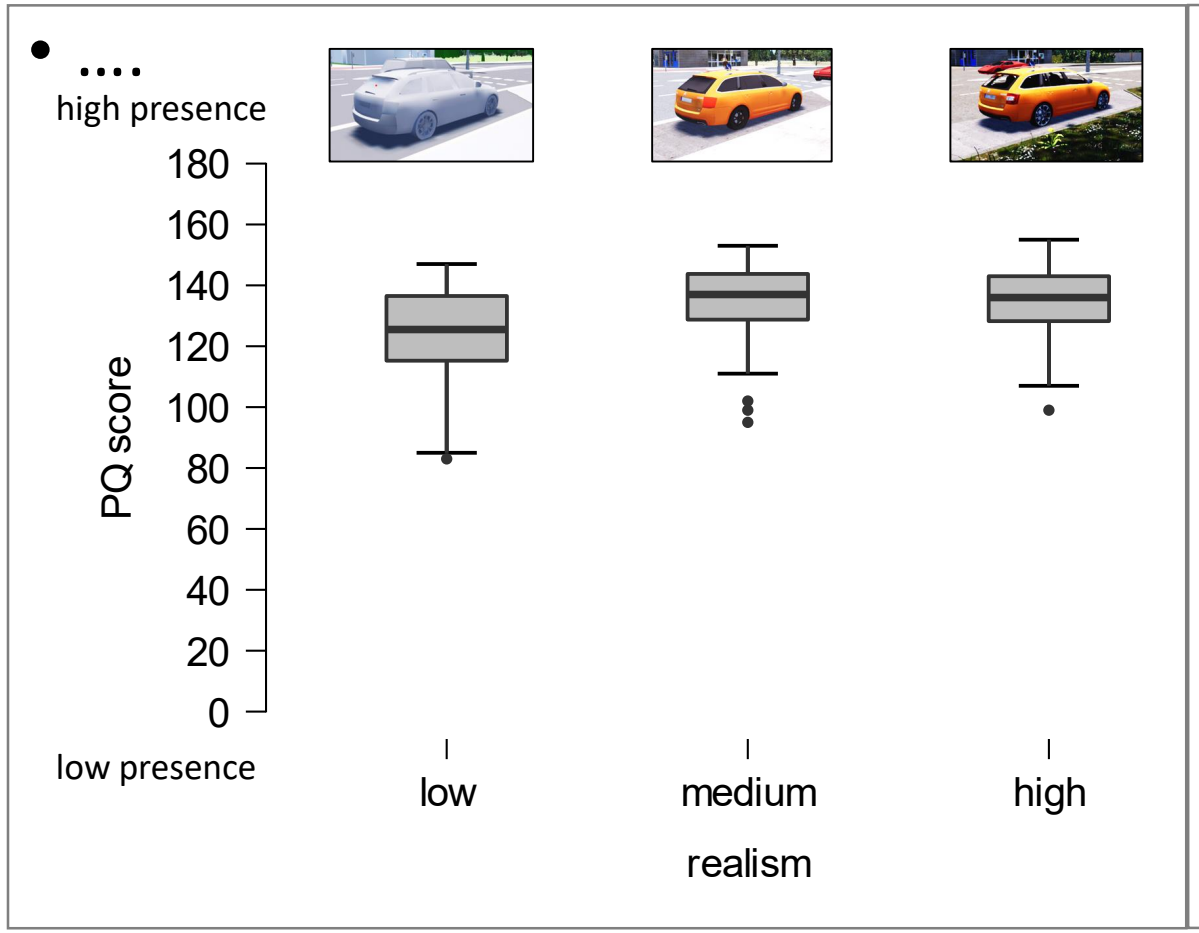
Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model (incl. subject)	0.500	$1.205e-4$	$1.205e-4$	1.000	
realism	0.500	1.000	8298.842	8298.842	1.040

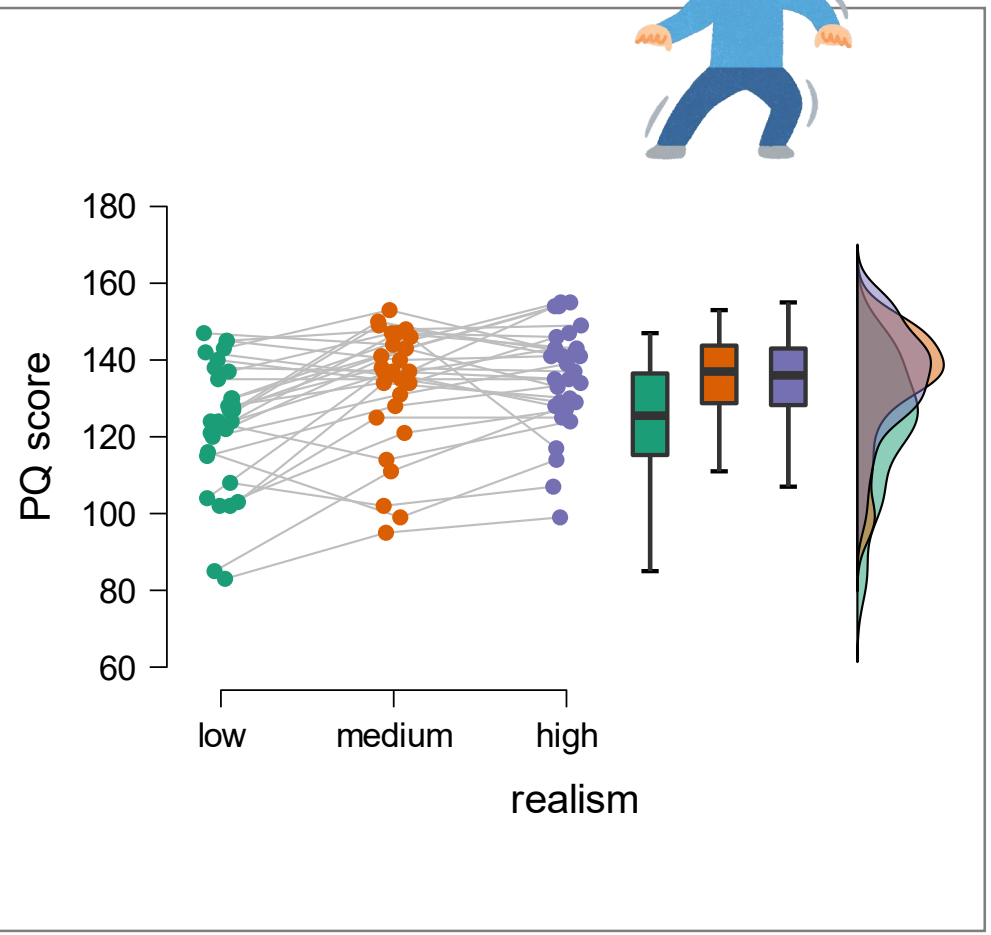
Table 8: Post Hoc comparison of the PQ rating for *realism*

		Prior Odds	Posterior Odds	$BF_{10,U}$	error %
low	medium	0.587	87.909	149.657	$1.518e-5$
	high	0.587	516.135	878.676	$1.210e-6$
medium	high	0.587	0.172	0.292	$2.851e-4$

Results - Presence

Effect of realism on the sense of presence

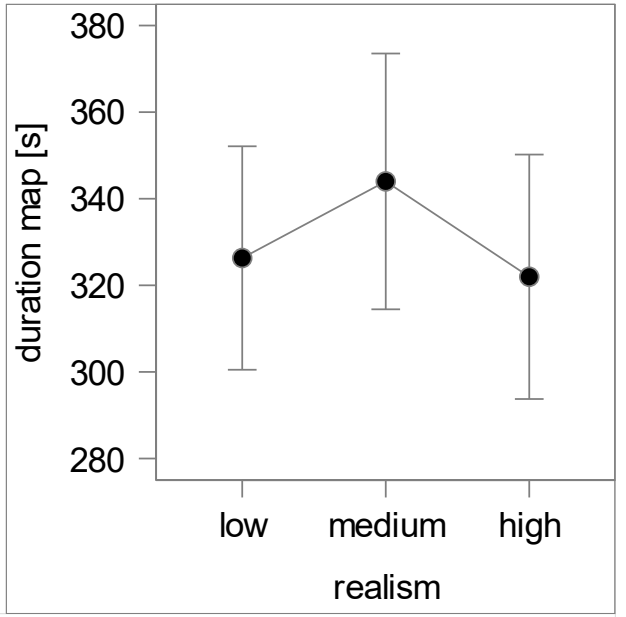




Results - Performance

Effect of realism on performance

- 11 assignments rated
- Moderate evidence for the H0
- Indicating no effect



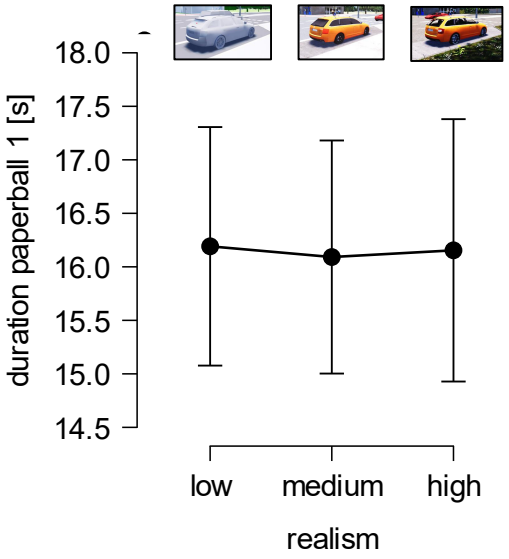
Model Comparison

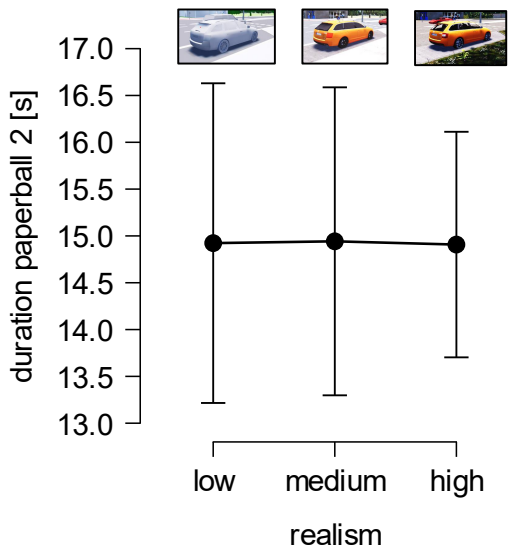
Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model (incl. subject)	0.500	0.799	3.980	1.000	
realism	0.500	0.201	0.251	0.251	0.597

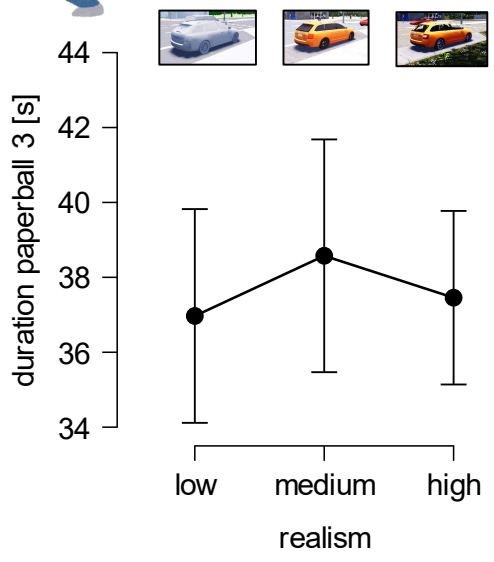
Note. All models include subject

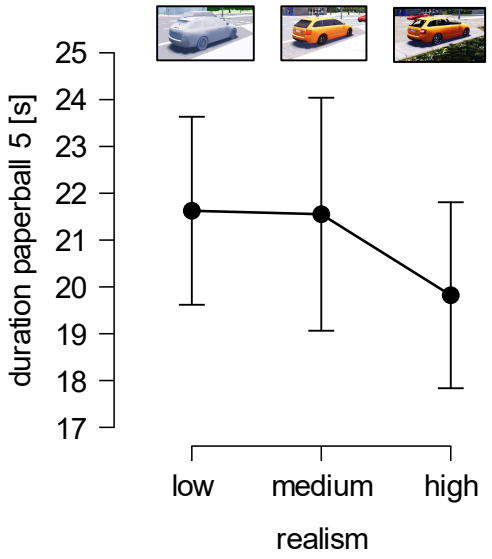
Results - Performance

Effect of realism on performance









Paperball 1

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Duration paperball 1					
Null model (incl. subject)	0.500	0.892		1.000	
realism	0.500	0.108		0.122	

Paperball 2

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Duration paperball 2					
Null model (incl. subject)	0.500	0.902		1.000	
realism	0.500	0.098		0.109	

Paperball 3

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Duration paperball 3					
Null model (incl. subject)	0.500	0.827		1.000	
realism	0.500	0.173		0.209	

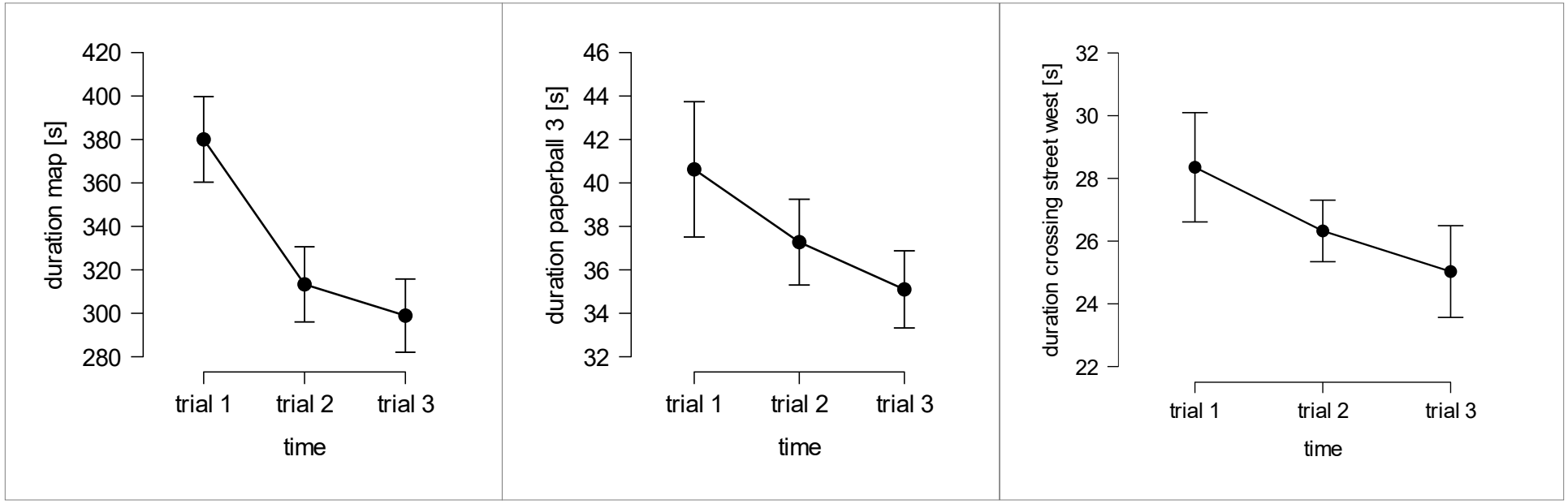
Paperball 5

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Duration paperball 5					
Null model (incl. subject)	0.500	0.803		1.000	
realism	0.500	0.197		0.245	

Results -Performance

Effect of time/trial number on performance

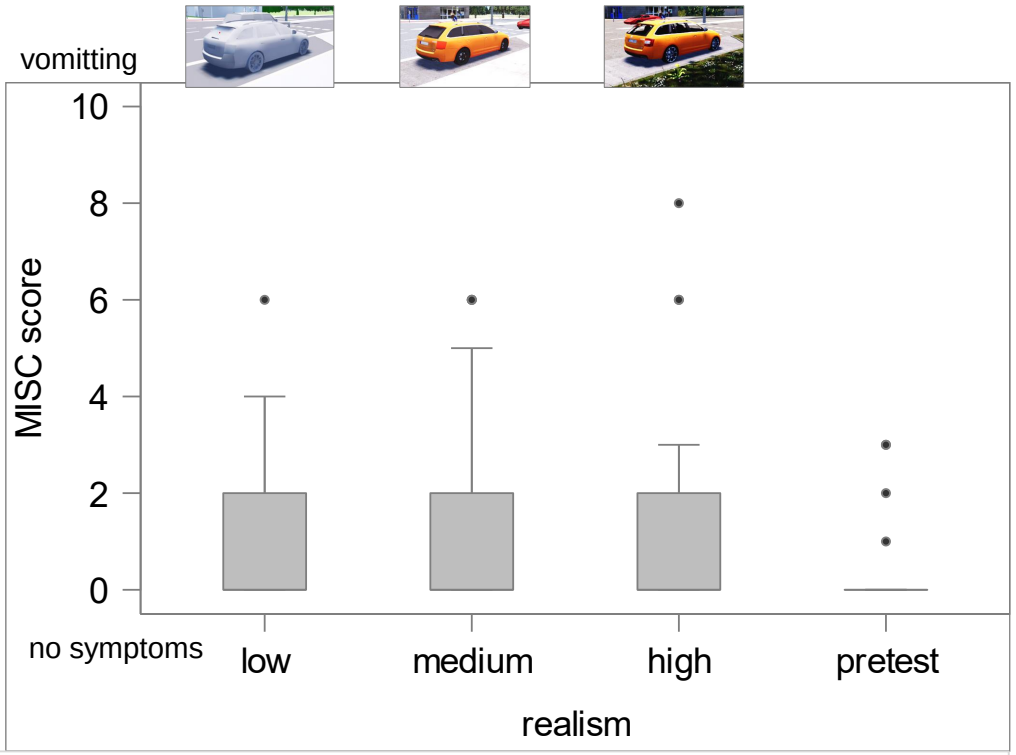
- Visible learning effect in several assignments
- Underlines importance of extensive and dedicated training scenarios



Results – Simulator Sickness

Effect of realism on simulator sickness

- Anecdotal evidence for the H0
- Indicating no relevant effect

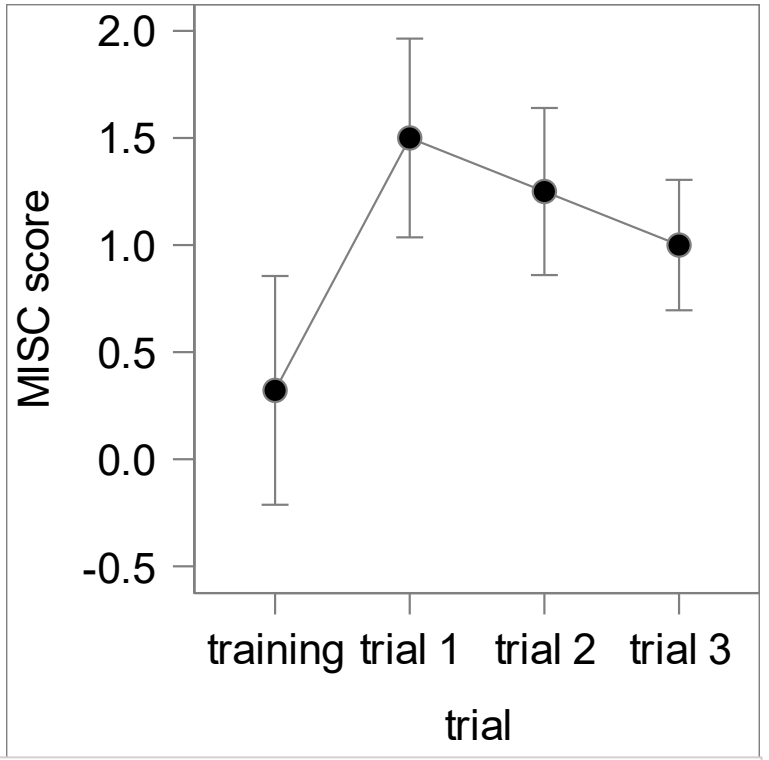


Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model (incl. subject)	0.500	0.690	2.225	1.000	
realism	0.500	0.310	0.449	0.449	0.588

Results – Simulator Sickness

Effect of time on simulator sickness

- Moderate evidence for the H0
- Indicating no relevant effect



Model Comparison

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model (incl. subject)	0.500	0.882	7.463	1.000	
trial	0.500	0.118	0.134	0.134	0.707

Note. All models include subject

Training excluded in evaluation

Results – Conclusion

- No effect between presence and performance
- Increased visual realism level also increases the feeling of presence
- Ceiling effect in medium condition
- Importance of appropriate training scenarios
- Low simulator sickness
- No negative correlation between presence and simulator sickness in pedestrian simulation

Outlook

- Further investigations concerning
  - Speed perception in 4 different simulators
  - Real-life benchmark study
  - Comparison of input devices for pedestrian/walking simulation

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THANK YOU

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