Understanding Cybersickness at Scale: Towards a Cross-Lab Experiment to Establish Standards for Immersive Experience Assessment

Dr. Daniel Zielasko

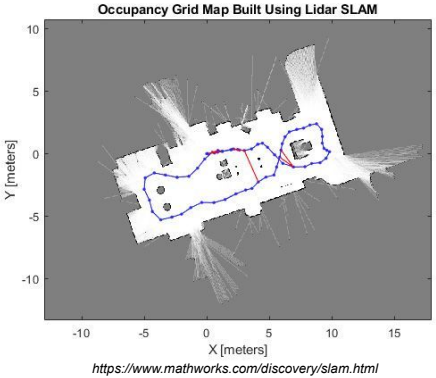
DTU

background

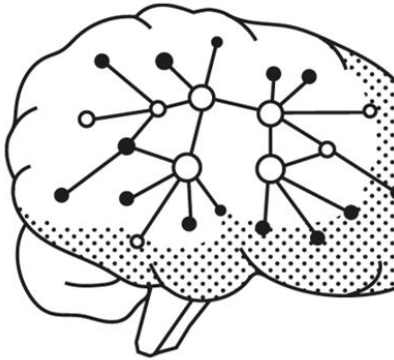
RWTH AACHEN UNIVERSITY

- **B. Sc. Computer Science**

„SLAM algorithms on a LEGO NXT”

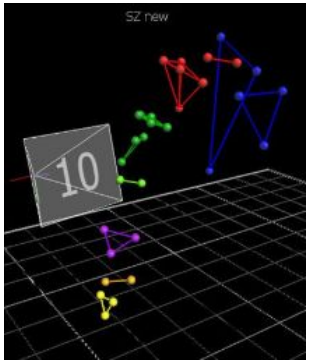


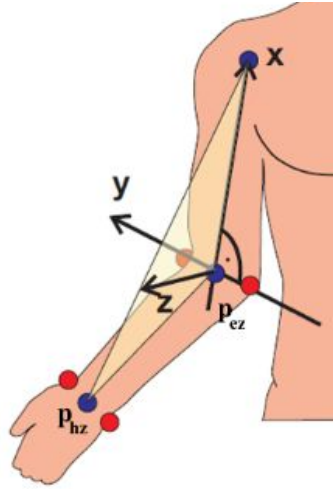
https://www.mathworks.com/discovery/slam.html



- **M. Sc. Computer Science**

Reduction of Disturbances When Determining Anatomical, Three-Dimensional Joint Angles of the Upper Extremities by Means of Optical 3D Tracking Systems

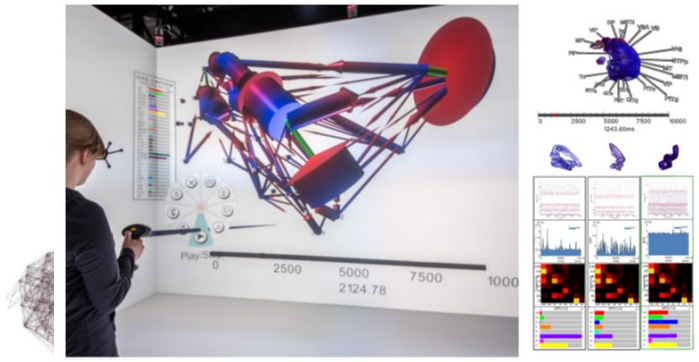




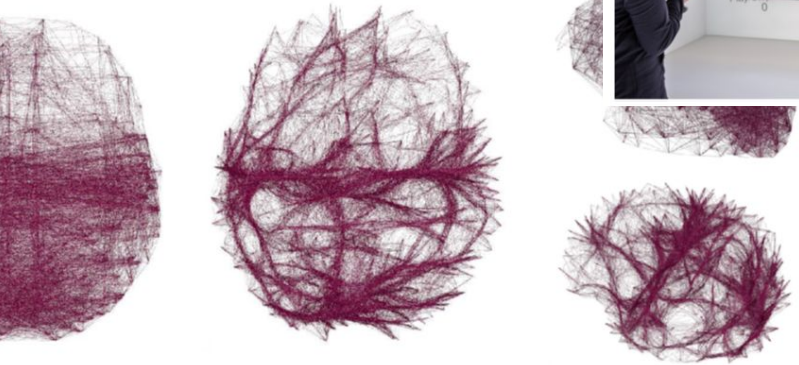
background

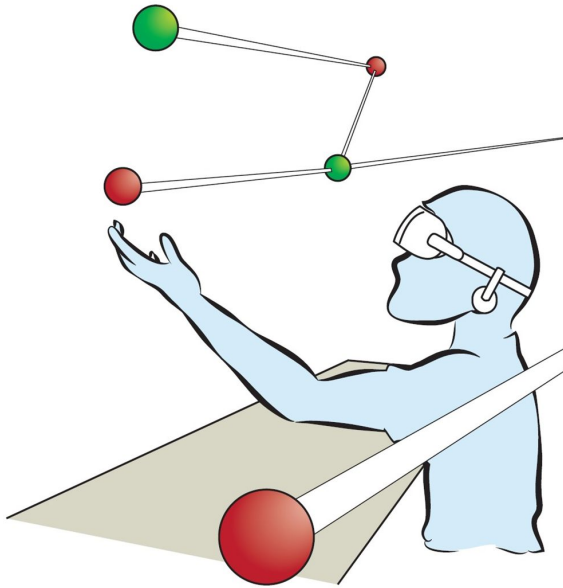
- **Dr. rer. nat.,** “deskVR”
  Immersive Analytics, 3D graph visualization

[Nowke 2013, Nowke, Zielasko, et al. 2015]

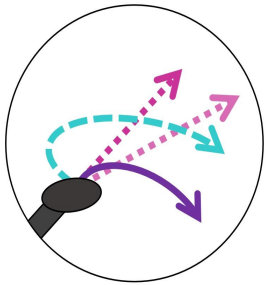


[Zielasko 2016, Zielasko 2020]





locomotion & transitions



Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation

fundamentals of egocentric teleportation

[Zielasko2020]

embodied-locomotion, ***leaning***

[Feld2024]

cross-reality transitions

Understanding Cybersickness at Scale: Towards a Cross-Lab Experiment to Establish Standards for Immersive Experience Assessment

DTU
Daniel Zielasko

Rift Coaster 2013

Content warning: Contains fast-moving or flickering visuals which may cause discomfort or trigger seizures.

I'm getting sick, this must be high fidelity!

https://www.youtube.com/watch?v=t7TntklfUgk

What is Cybersickness?

[Stanney1997]
Simulator Sickness Questionnaire (SSQ)

vestibular system

visual system

English version	Deutsche Version	none / nicht
General discomfort	Allgemeines Unwohlsein	
Fatigue	Müdigkeit	
Headache	Kopfschmerz	
Eye strain	Überanstrengte Augen	
Difficulty focusing	Probleme zu fokussieren	
Salivation increasing	Erhöhter Speichelfluss	
Sweating	Schwitzen	
Nausea	Übelkeit	
Difficulty concentrating	Schwierigkeiten zu Konzentrieren	
Fullness of the head	Voller Kopf	
Blurred vision	Verschwommene Sicht	
Dizziness with eyes open	Schwindel bei geoffneten Augen	
Dizziness with eyes closed	Schwindel mit geschlossenen Augen	
Vertigo*	Drehschwindel*	
Stomach awareness**	Der Magen macht sich bemerkbar**	
Burping	Aufstoßen	

* Vertigo is experienced

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[Stanney1997]
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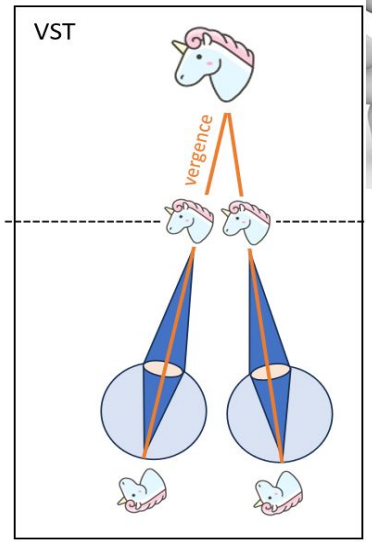

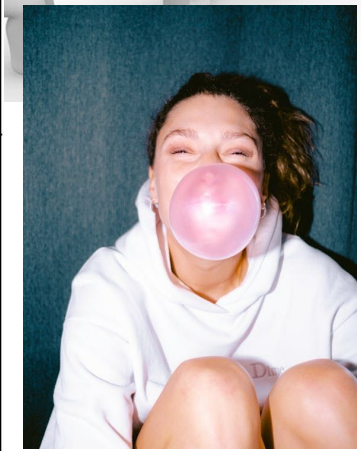

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Feld, N., Pointecker, F., Anthes, C., & **Zielasko, D**. (2024, October). Perceptual Issues in Mixed Reality: A Developer-oriented Perspective on Video See-Through Head-Mounted Displays. In *2024 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)* (pp. 170-175). IEEE.

What is Cybersickness?

Do we consider dry eyes or eye strain from long display use symptoms of cybersickness?

Do we consider a headache after wearing a heavy or tight HMD for 2 hours considered cybersickness?

Brown, P., Spronck, P., & Powell, W. (2022). **The simulator sickness questionnaire, and the erroneous zero baseline assumption**. *Frontiers in Virtual Reality*, *3*, 945800.

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	Aufstoßen	

Now, knowing what Cybersickness is…

~~**Now, knowing what Cybersickness is…**~~

Now, sort of knowing what we consider to by Cybersickness…

Why?

“Cybersickness has a well-established causal link to visual–vestibular conflict, although the underlying mechanisms remain largely unknown.”

Only a few hypotheses are around…

Poison Theory

~~Now, knowing what Cybersickness is…~~

Now, sort of knowing what we consider to by Cybersickness…

Why?

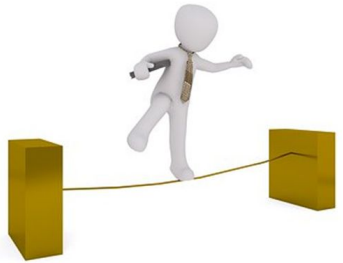
“Cybersickness has a well-established causal link to visual–vestibular conflict, although the underlying mechanisms remain largely unknown.”

Only a few hypotheses are around…

Does there have to be a plausible reason?

Poison ~~Theory~~ Hypothesis

Postural Instability Theory



LaViola Jr, J. J. (2000). A discussion of cybersickness in virtual environments. *ACM Sigchi Bulletin*, *32*(1), 47-56.

What do we actually know?

Some observations and correlections are repeatedly found:

- a majority of people is affected after extended XR sessions
  (w/ respective stimuli, e.g. virtual movement)
- inter individual differences are huge
- few people are hypersensitive, few are not affected at all
  - cybersickness still exists
- prior experience of cybersickness is maybe currently the strongest predictor for individual sickness
- there is a small correlation with sex, and other individual factors
- there seems to be habituation to some extent
  careful the change seems to be larges from 0 to 1 time users
- mitigation techniques exist
- there is a temporal component/extension

D. Zielasko, "Subject 001 - A Detailed Self-Report of Virtual Reality Induced Sickness," *2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, Lisbon, Portugal, 2021, pp. 165-168, doi: 10.1109/VRW52623.2021.00038.

J. W. Kelly, S. B. Gilbert, M. C. Dorneich and K. A. Costabile, "Gender differences in cybersickness: Clarifying confusion and identifying paths forward," 2023 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), Shanghai, China, 2023, pp. 283-288, doi: 10.1109/VRW58643.2023.00067

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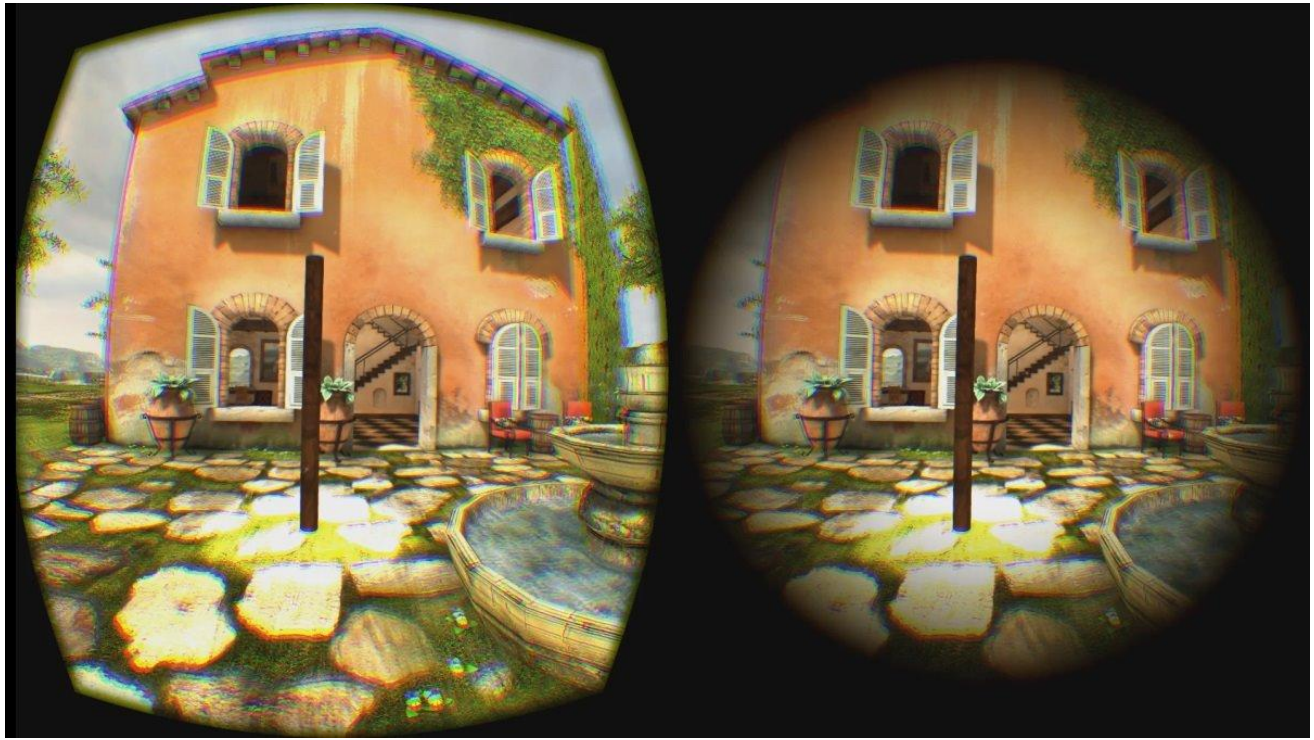
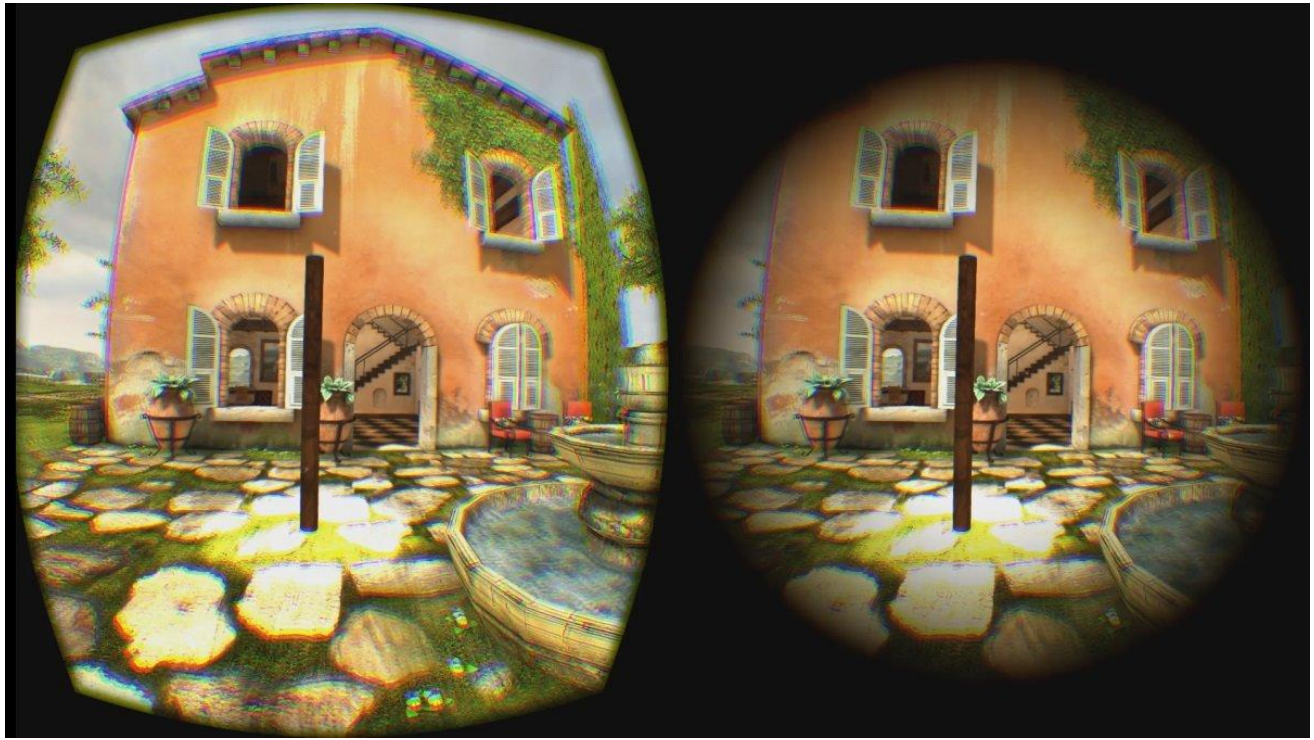
mitigation techniques exist

field of view restriction/modification



A. S. Fernandes and S. K. Feiner, "Combating VR sickness through subtle dynamic field-of-view modification," *2016 IEEE Symposium on 3D User Interfaces (3DUI)*, Greenville, SC, USA, 2016, pp. 201-210, doi: 10.1109/3DUI.2016.7460053.

mitigation techniques exist… but most of them are restrictive, do have potential negative effect on UX



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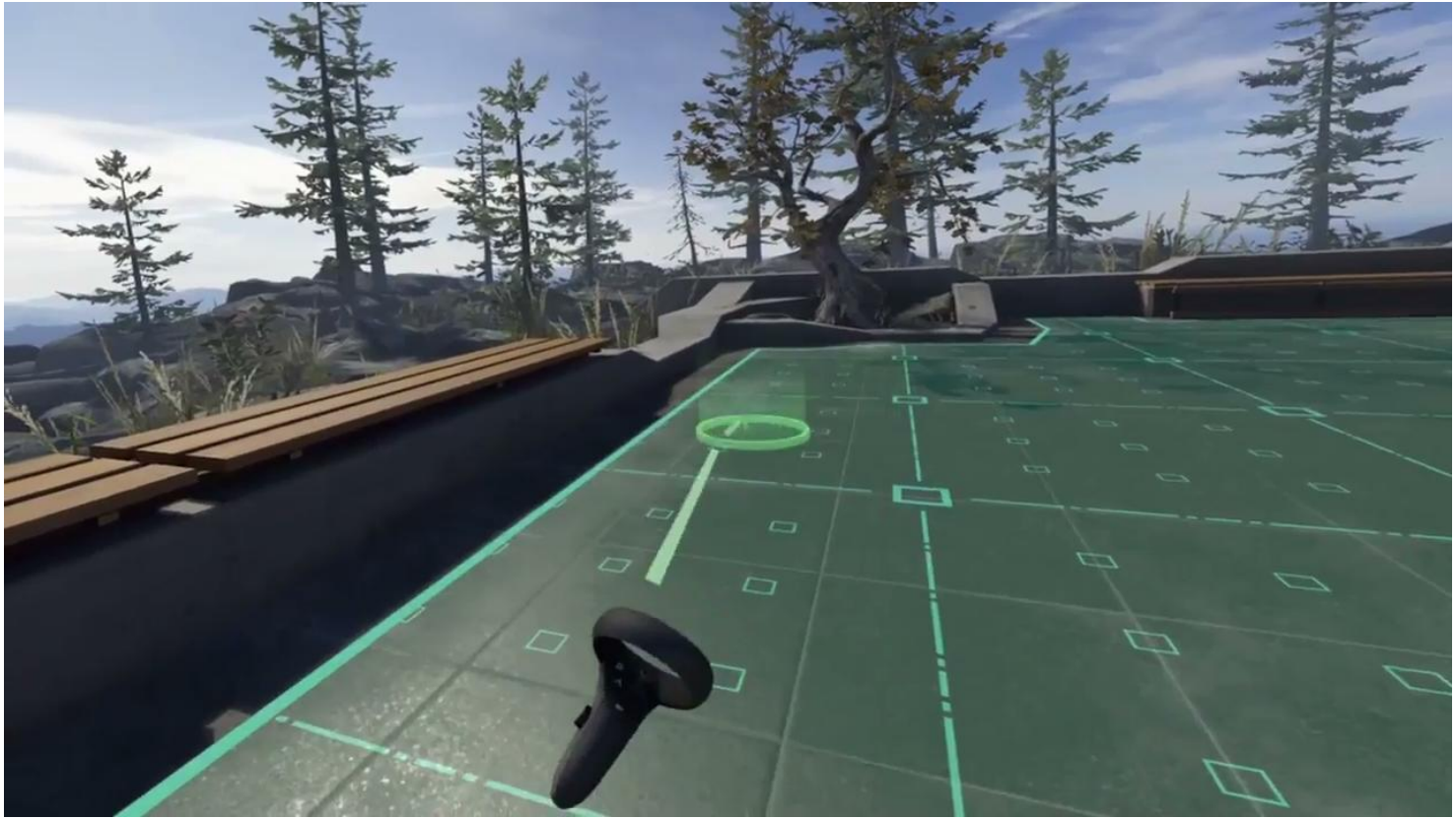
“but Daniel, is bad UX not better then getting sick?”



“but Daniel, is bad UX not better then getting sick?”
“yeah, maybe but it's still a bad UX”

The Relationship Between Time and Distance Perception in Egocentric Target-Selection-Based Teleportation

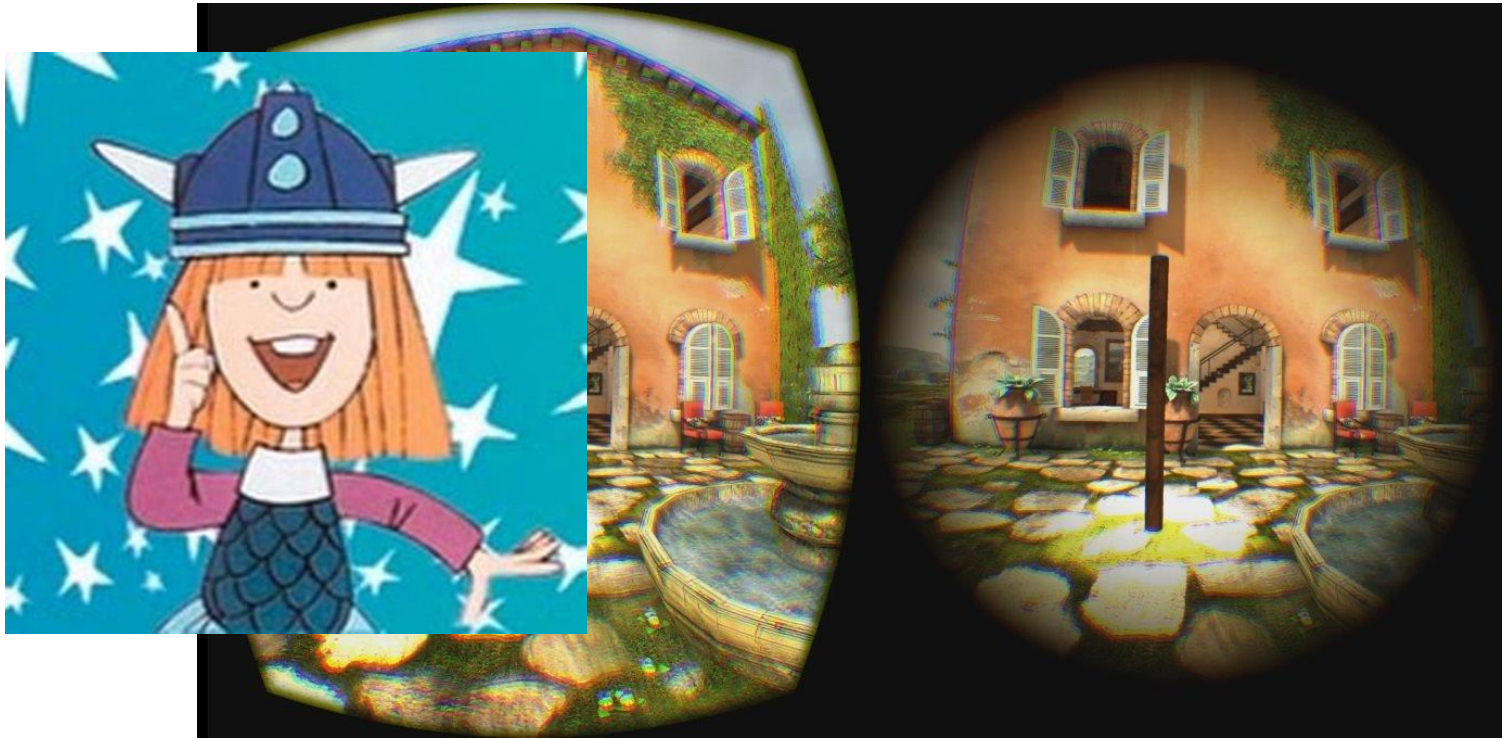
Locomotion Interfaces

Matthias Wölwer, Daniel Zielasko
IEEE ISMAR 2025

Wölwer, M., & **Zielasko, D**. (2025). The Relationship Between Time and Distance Perception in Egocentric and Discrete Virtual Locomotion. IEEE ISMAR 2025

N. Feld, N. Dubois, P. Bimberg, B. Weyers and **D. Zielasko**, "Dashing: Fun but Non-Ergonomic? Exploring Transition Effects in VR," *2025 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, Saint Malo, France, 2025, pp. 246-252, doi: 10.1109/VRW66409.2025.00060.

ok for a moment let’s assume we can life and reliable measure sickness



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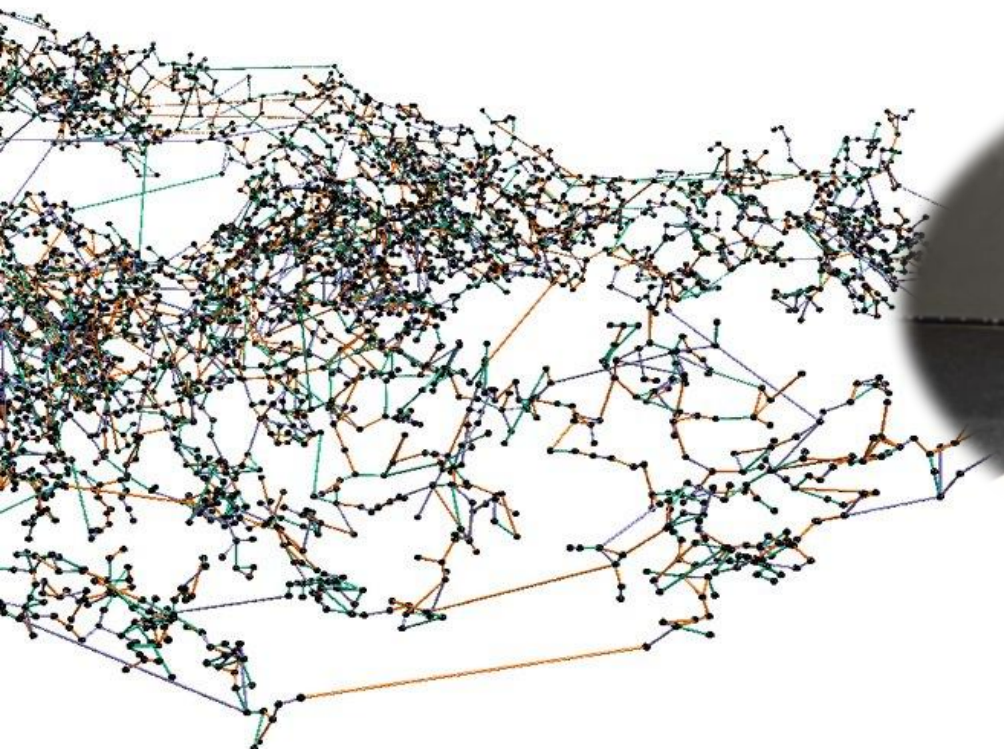
Dynamic Field of View Reduction Related to Subjective Sickness Measures in an HMD-based Data Analysis Task
D Zielasko, A Meißner, S Freitag, B Weyers, TW Kuhlen. 2018

between-subject 16 vs. 16

Restricted FoV
110°- 44°

vs.

Regular FoV
110°



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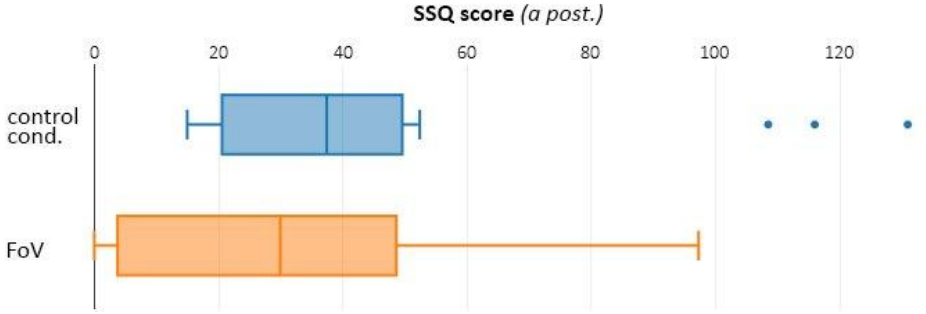

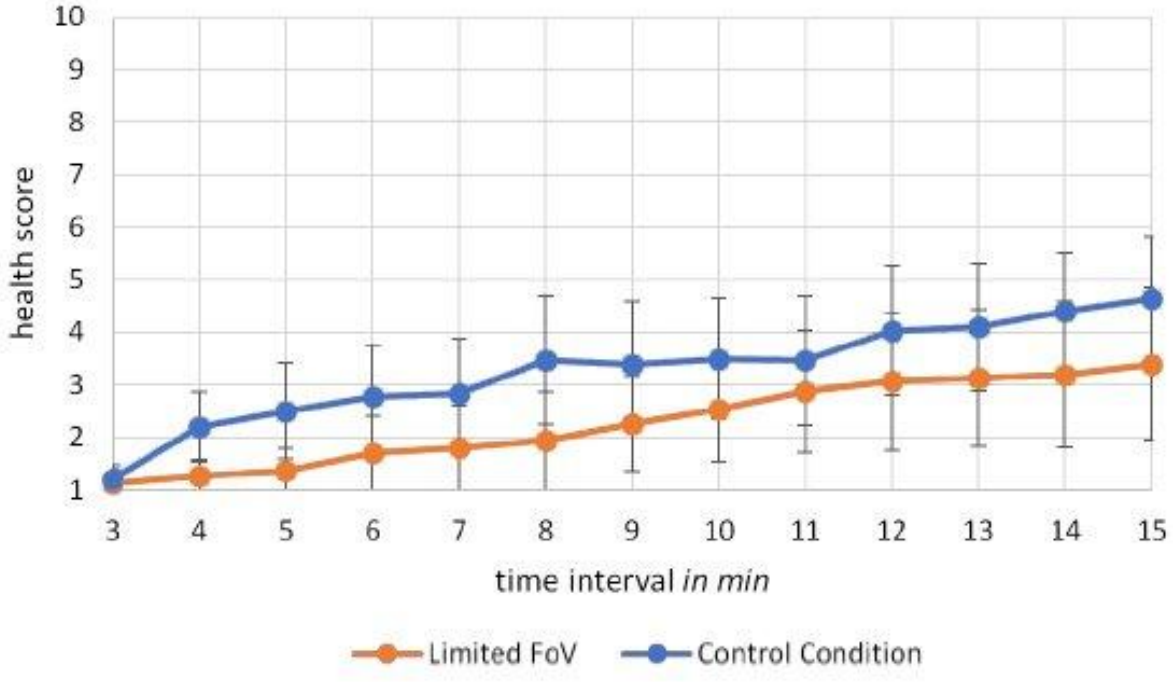

What do we actually know?

*even in combination, their effect is limited for a lot of user, effectively not letting them participate in XR

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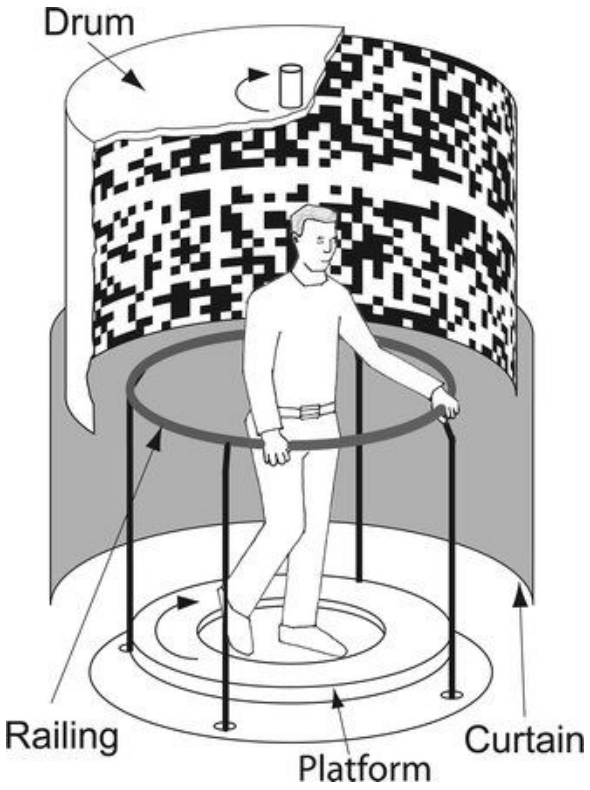
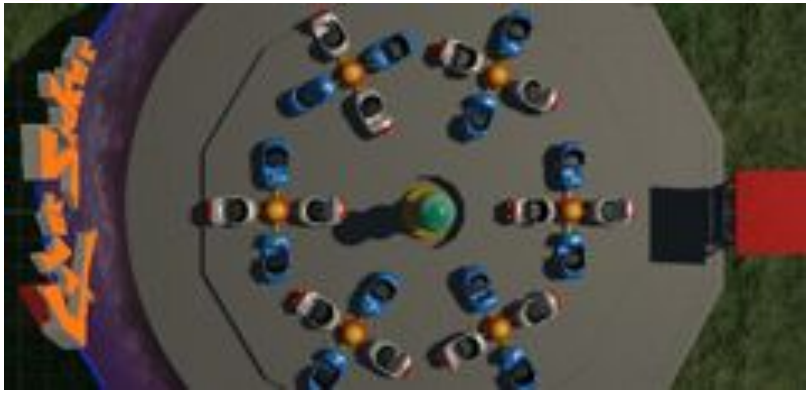
to research temporal extension a controlled stimulation is required



a roller coaster experience is more or less stable between participants but timing and intensity of stimulation are hard to control

Becker, W., Kliegl, K., Kassubek, J. *et al.* Podokinetic circular vection: characteristics and interaction with optokinetic circular vection. *Exp Brain Res* 234, 2045–2058 (2016). https://doi.org/10.1007/s00221-016-4604-x

Open Cybersicker



Daniel Zielasko and Yuen C. Law. 2024. Cybersicker: An Open Source VR Sickness Testbed - Do you still have fun, or are you already sick? In Proceedings of the 30th ACM Symposium on Virtual Reality Software and Technology (VRST '24). Association for Computing Machinery, New York, NY, USA, Article 91, 1–2. https://doi.org/10.1145/3641825.3689503

Open Cybersicker

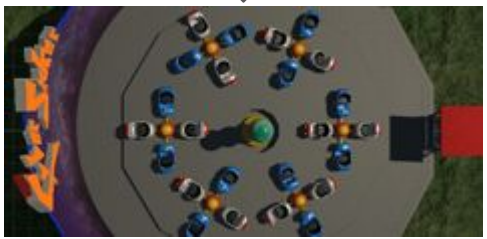
experiment

Do Not Immerse and Drive! Subjective and Psycho-Endocrinological Temporal Extension of Cybersickness Symptoms and Perception of Self-Recovery (under review) **Daniel Zielasko**, Ben Rehling, Bernadette von Dawans, Gregor Domes

under review

male/female: 15/15; aged 19-44 years

study ← exactly 1 week → control



~90 minutes

measures

- SSQ
- FMS
- salivary cortisol
- alpha amylase
- n-back task (t = 30min)
- …

results

Do Not Immerse and Drive! Subjective and Psycho-Endocrinological Temporal Extension of Cybersickness Symptoms and Perception of Self-Recovery (under review) **Daniel Zielasko**, Ben Rehling, Bernadette von Dawans, Gregor Domes

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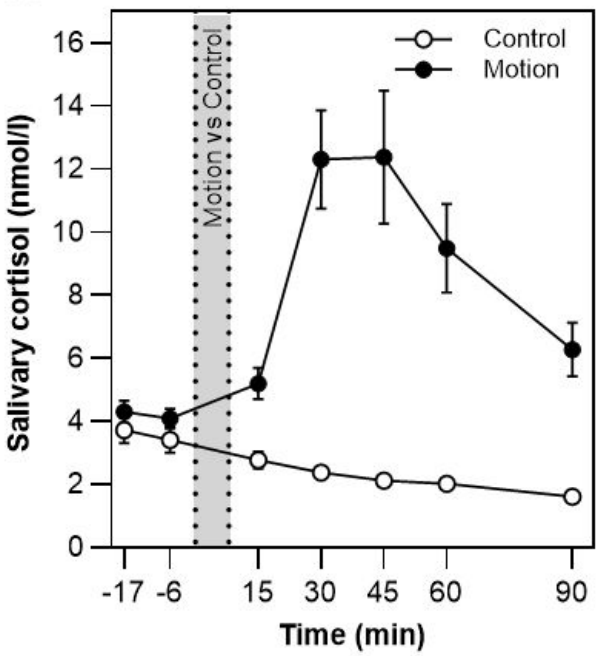

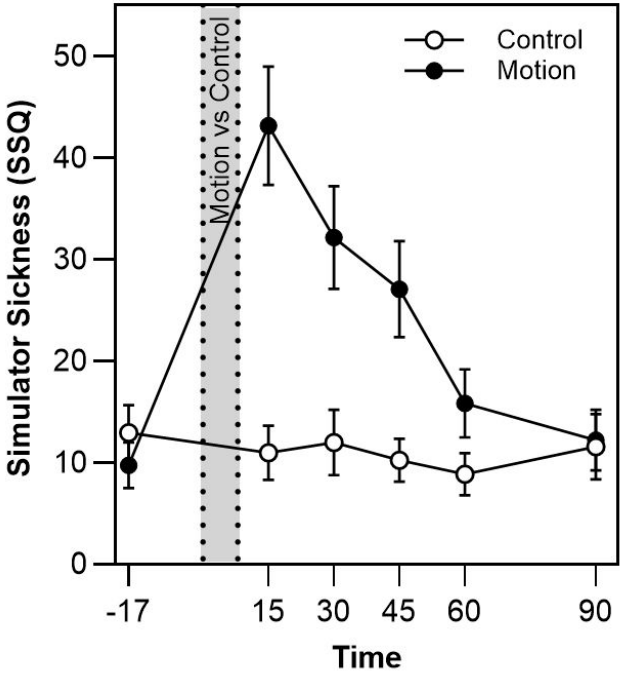

Thanks!

Open Cybersicker

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danzi@dtu.dk

daniel.zielasko@rwth-aachen.de