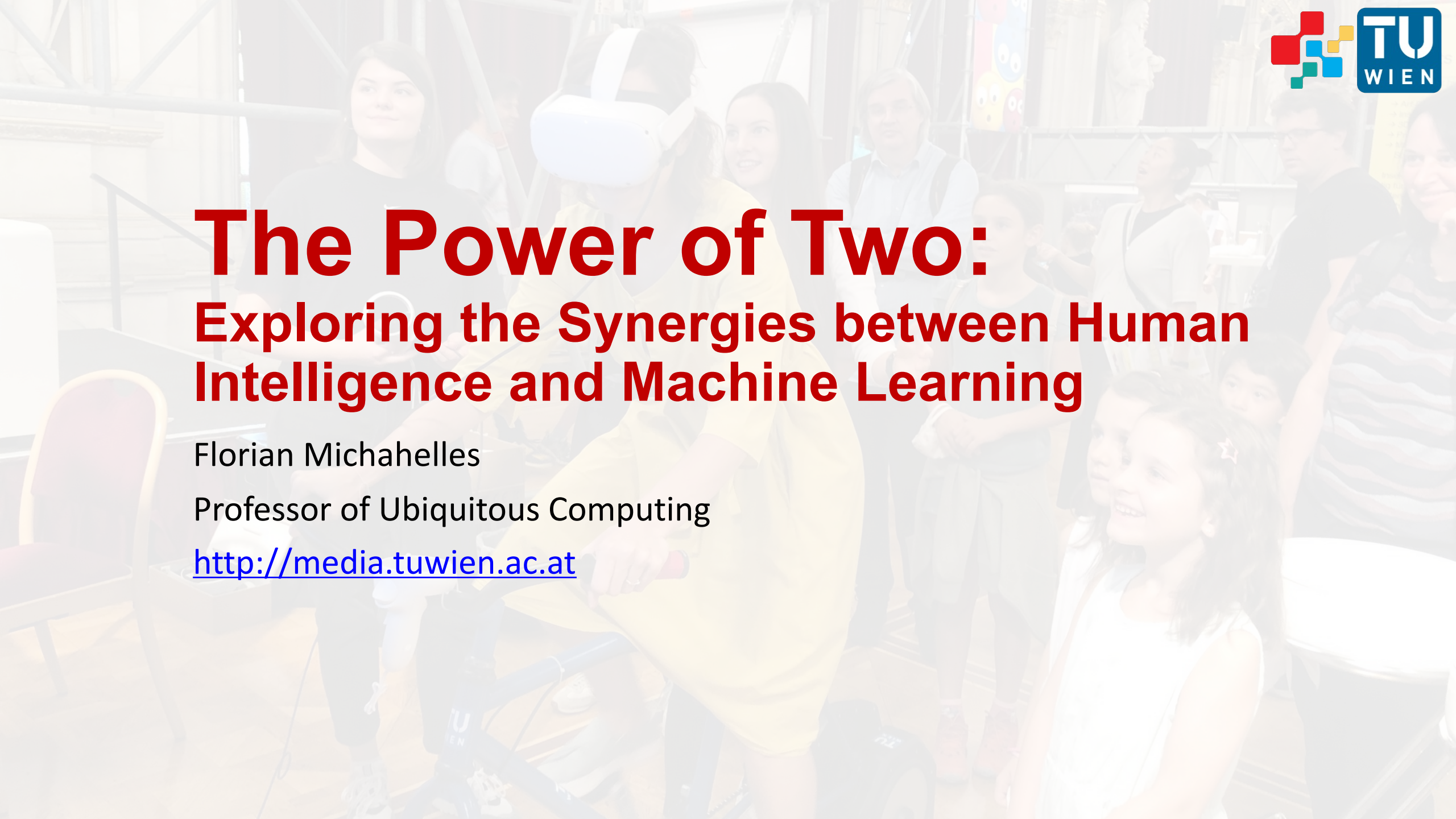


The Power of Two:

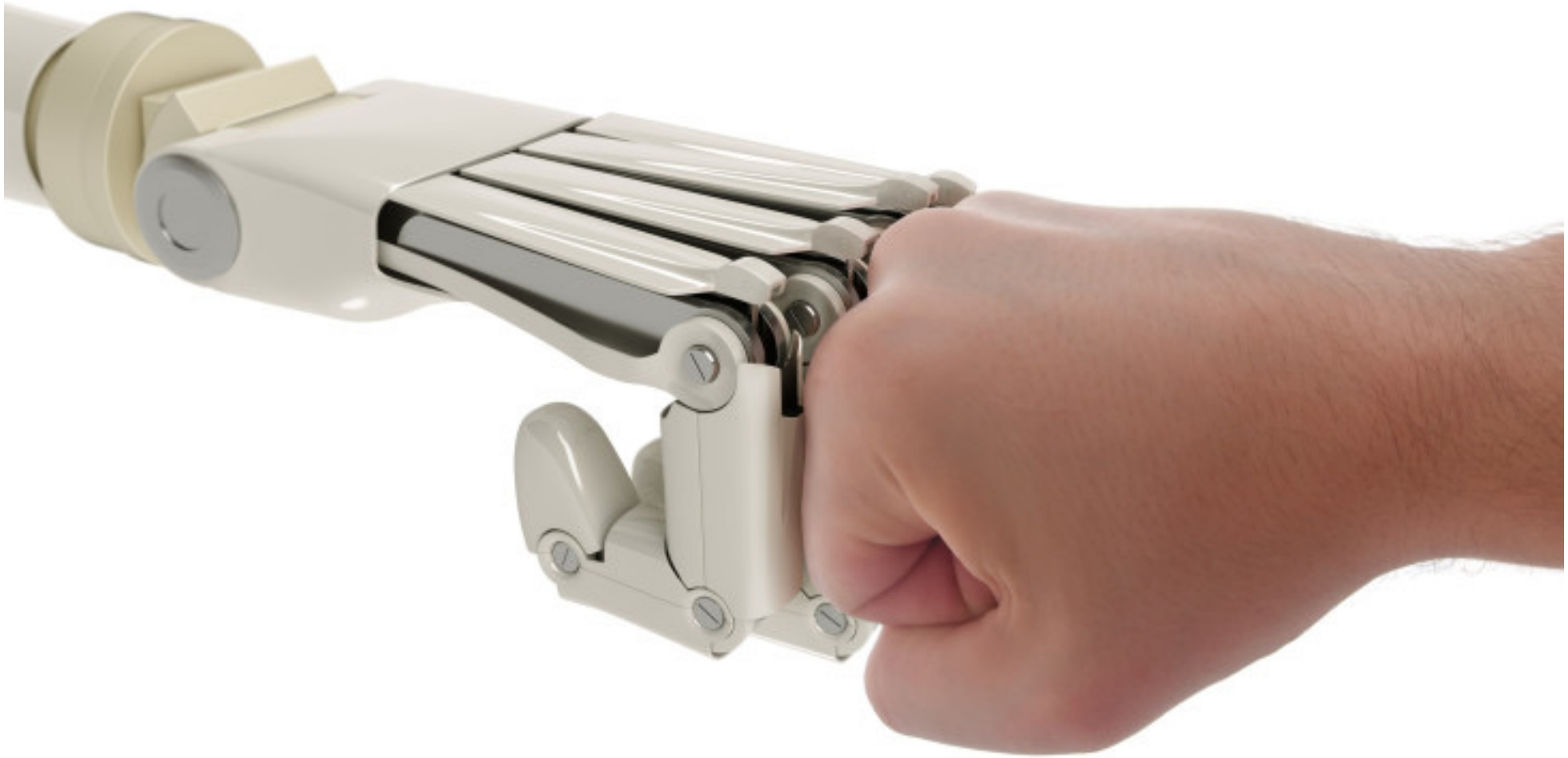
Exploring the Synergies between Human Intelligence and Machine Learning

Florian Michahelles

Professor of Ubiquitous Computing

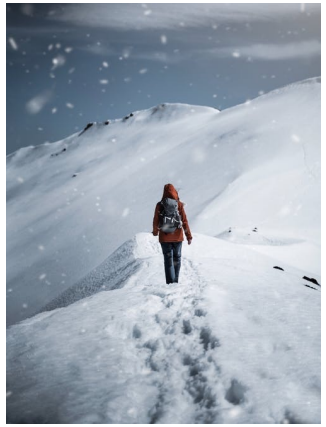
http://media.tuwien.ac.at

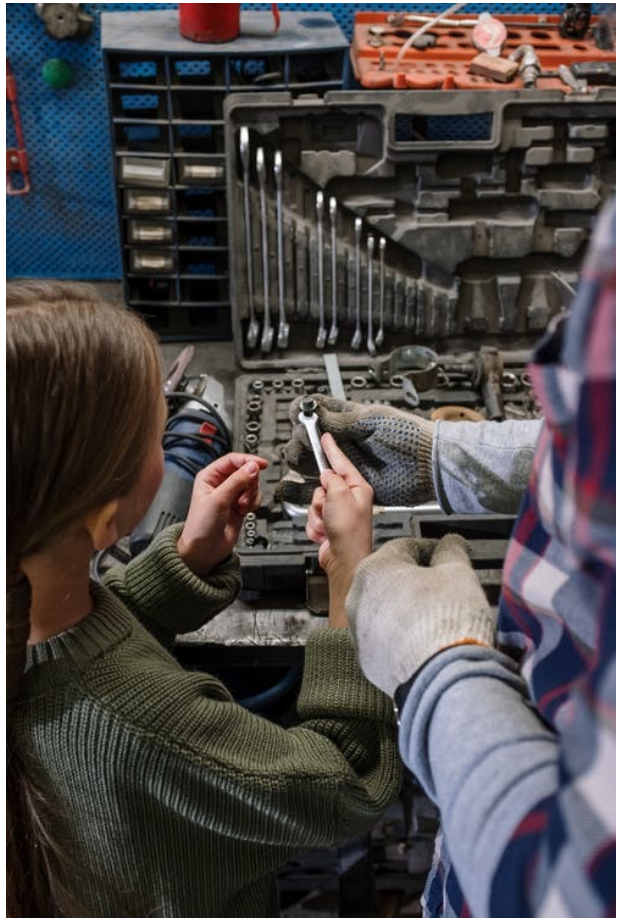
What the human can do the machine can’t do
→ and what they can do better together



Human deprived being

- Arnold Gehlen's Anthropology (1904-1976)
  - Unfinished character of human organism
  - Unspecific to environment (instinctual deprivation)
  - Construct own world





Peter L. Berger and Hansfried Kellner, "**Arnold Gehlen and the Theory of Institutions**," Social Research, vol. 32, no. 1 (Spring 1965): 110–115

Humans and machines

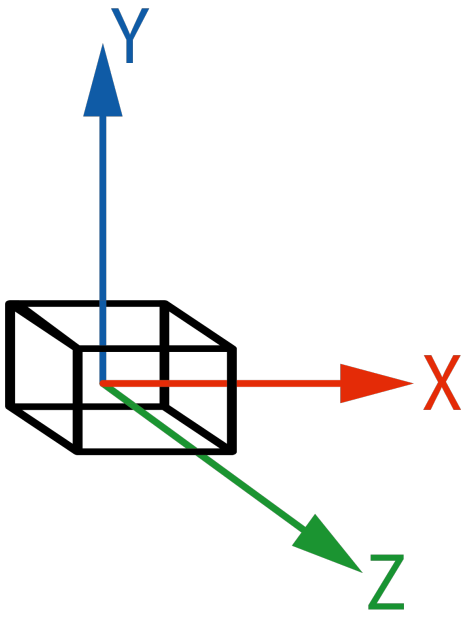
1. Critical thinking
2. Strategic thinking
3. Creativity
4. Empathy and communication skills
5. Imagination
6. Psychical skills
7. Technical know-how

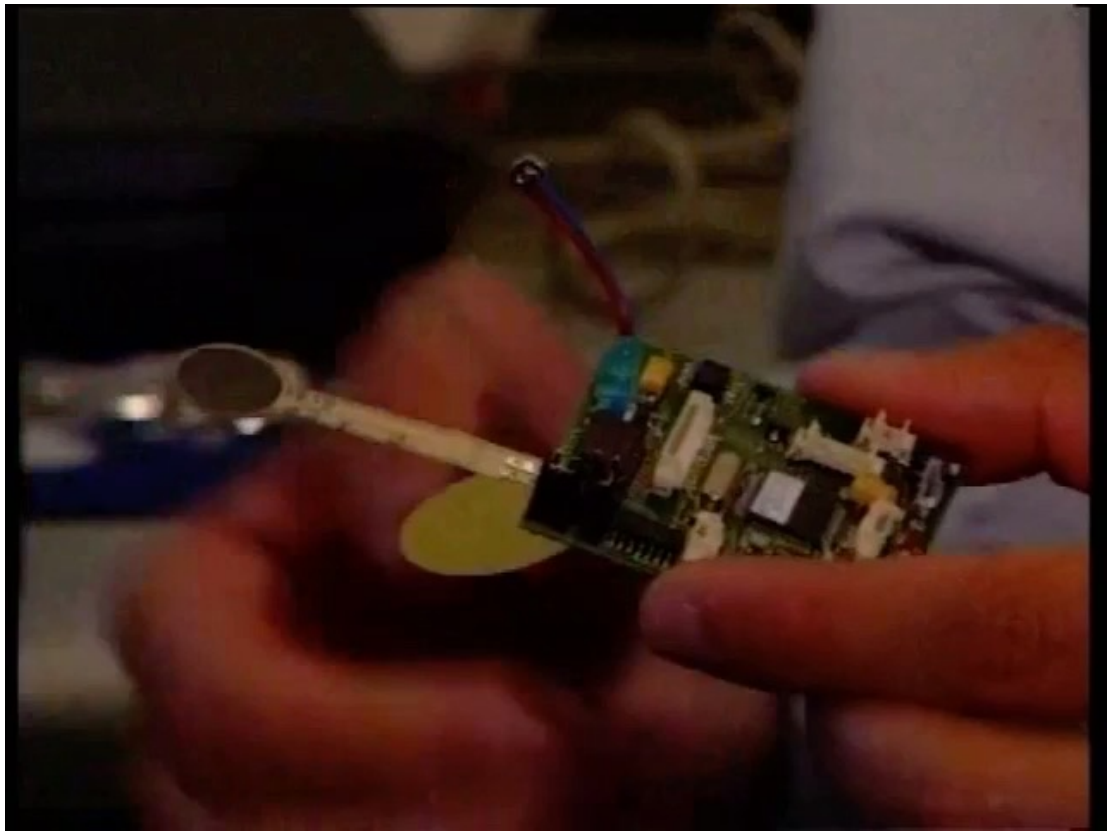
1. Handling tedium:
   - monotonous duties
2. Extreme sensing
3. Strength and speed
4. Unwavering focus
5. Perfect, objective recall
   - **Drive you around** in relative safety. ...
   - **Book things** for you by phone. ...
   - **Write marketing language** which outperforms **humans**.
   - **Understand you** (most of the time) ...
   - **Predict which movies**/TV shows/songs/products you'll like with a reasonable degree of accuracy.

- perceive
- feedback
- collaboration
- experience

First step: perceiving user actions

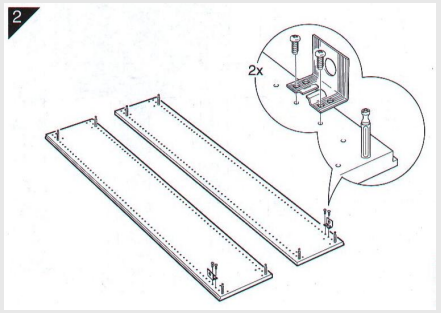
- Users' Context in Smart Environments

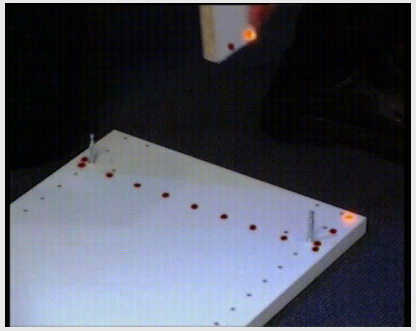




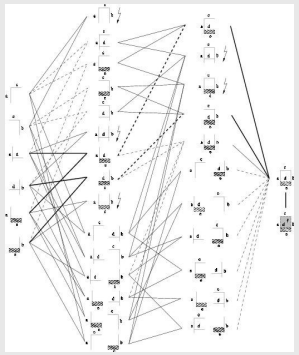
Antifakos, Stavros, Florian Michahelles and Bernt Schiele. “Proactive Instructions for Furniture Assembly.” UbiComp (2002). 10.1007/3-540-45809-3_27

Second step: feedback

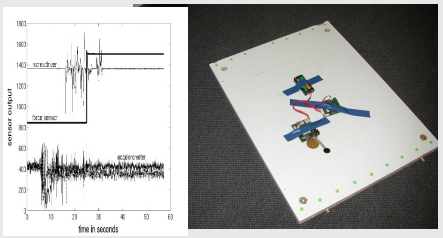




1. Improve classic instructions



2. Assembly plan



3. Perceiving actions with sensors

4. Proactive Instructions

Antifakos, Stavros et al. “Proactive Instructions for Furniture Assembly.” *UbiComp* (2002).

Digital Lathe Companion

Turn-by-Wire: Computationally Mediated Physical Fabrication, Rundong Tian, Vedant Saran, Mareike Kritzler, Florian Michahelles, and Eric Paulos, ACM UIST, Oct 2019.

Just Dance

We want to find out if EMS supported learning of motoric tasks (demonstrated on the example of dancing) can reduce the training time, compared to classical skill acquisition?

We picked a subsection of Indian dance form called ‘Hand Mudras’ as a task. We decide on a set of Mudra sequences to train the users on.

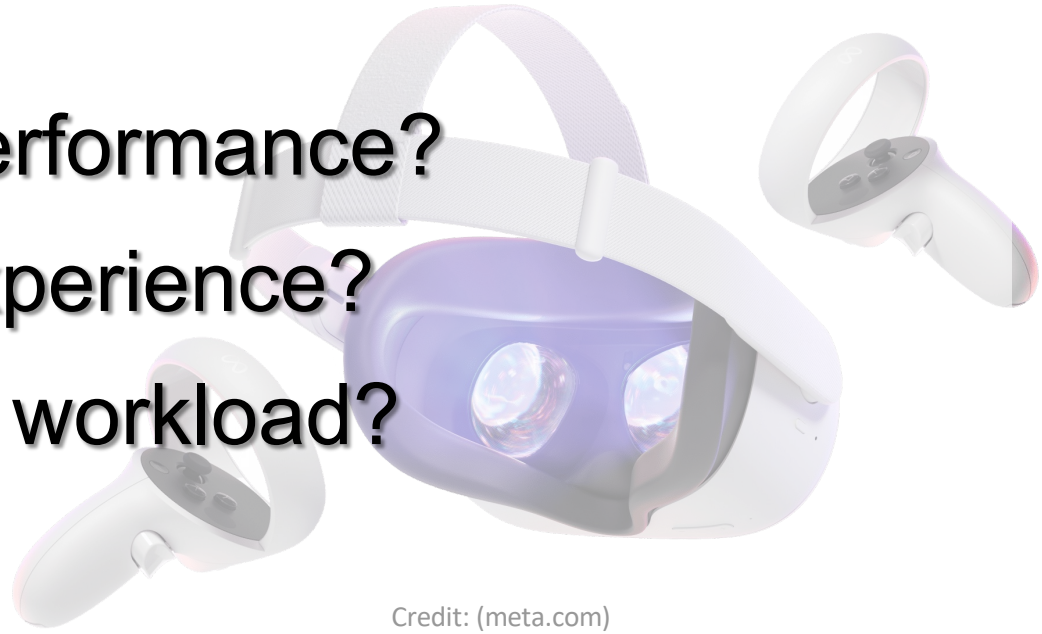
Third step: human machine collaboration

How can a team of humans and machines be more successful than either humans or technology alone?

Study Environment

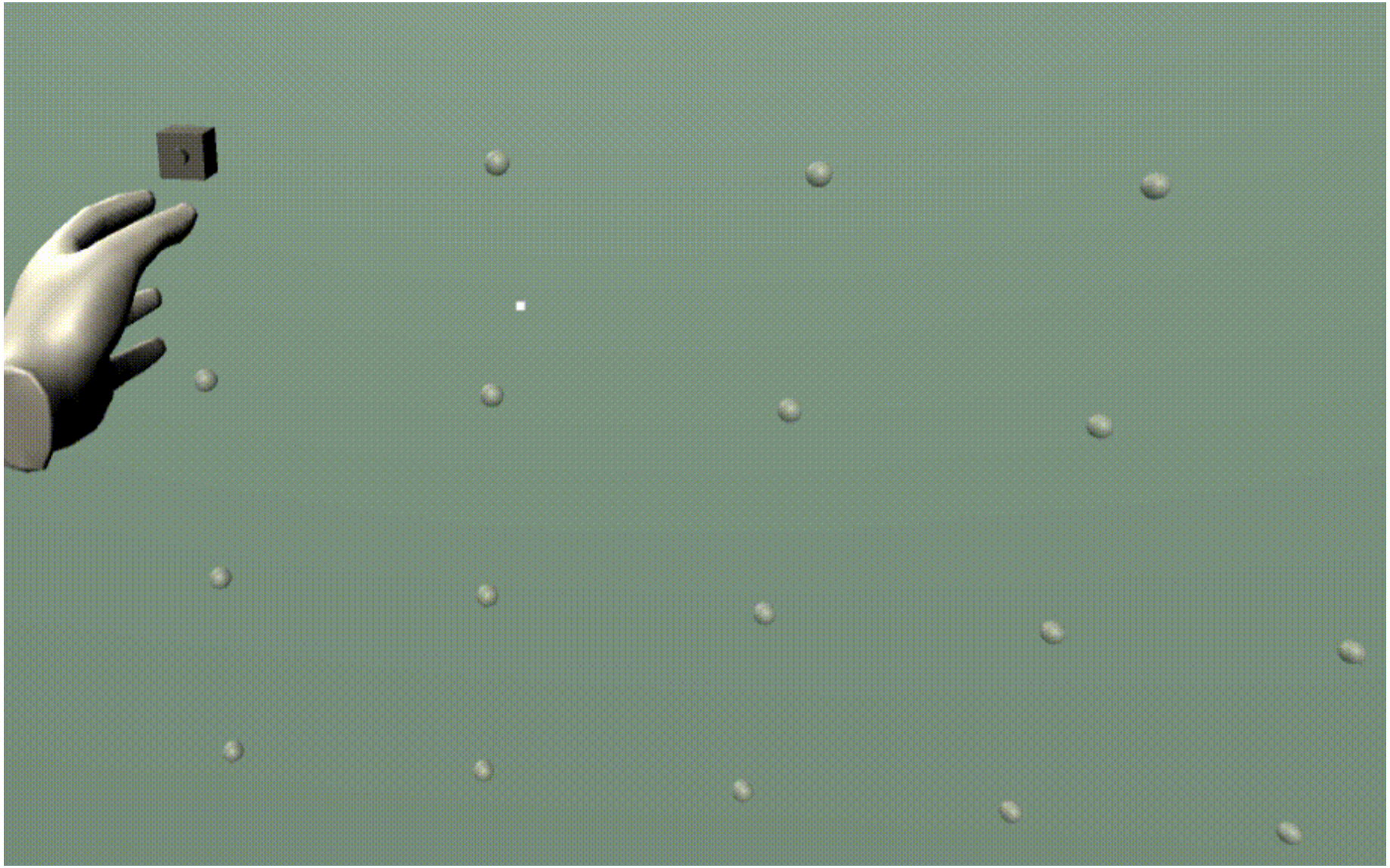
Given a visually-obstructed, collaborative task between a human and robot, which feedback modalitie(s) are most suited to...

- RQ1: improve the human's performance?
- RQ2: provide a better user experience?
- RQ3: minimize the operator's workload?

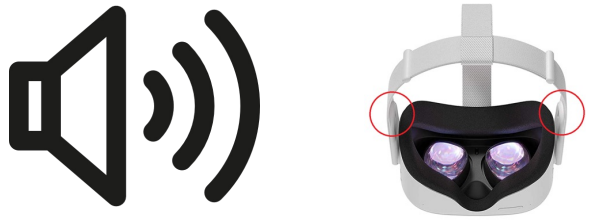
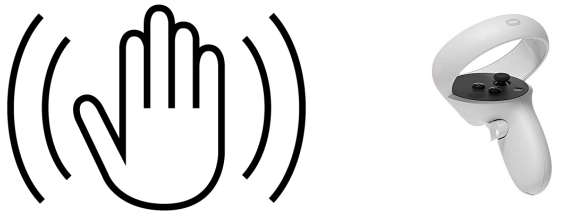


Credit: (meta.com)

Study Task



Findings

			
▪ Highest performance improvement ▪ Highest pragmatic UX ▪ Lowest cognitive load	▪ Improvement over baseline ▪ Participants indicated effectiveness communicating pace	▪ Least useful practically ▪ Highest hedonic rating ▪ Possible learning curve	▪ Significant performance improvement ▪ Low cognitive load ▪ More resilient to noise ▪ Possible sensory overload

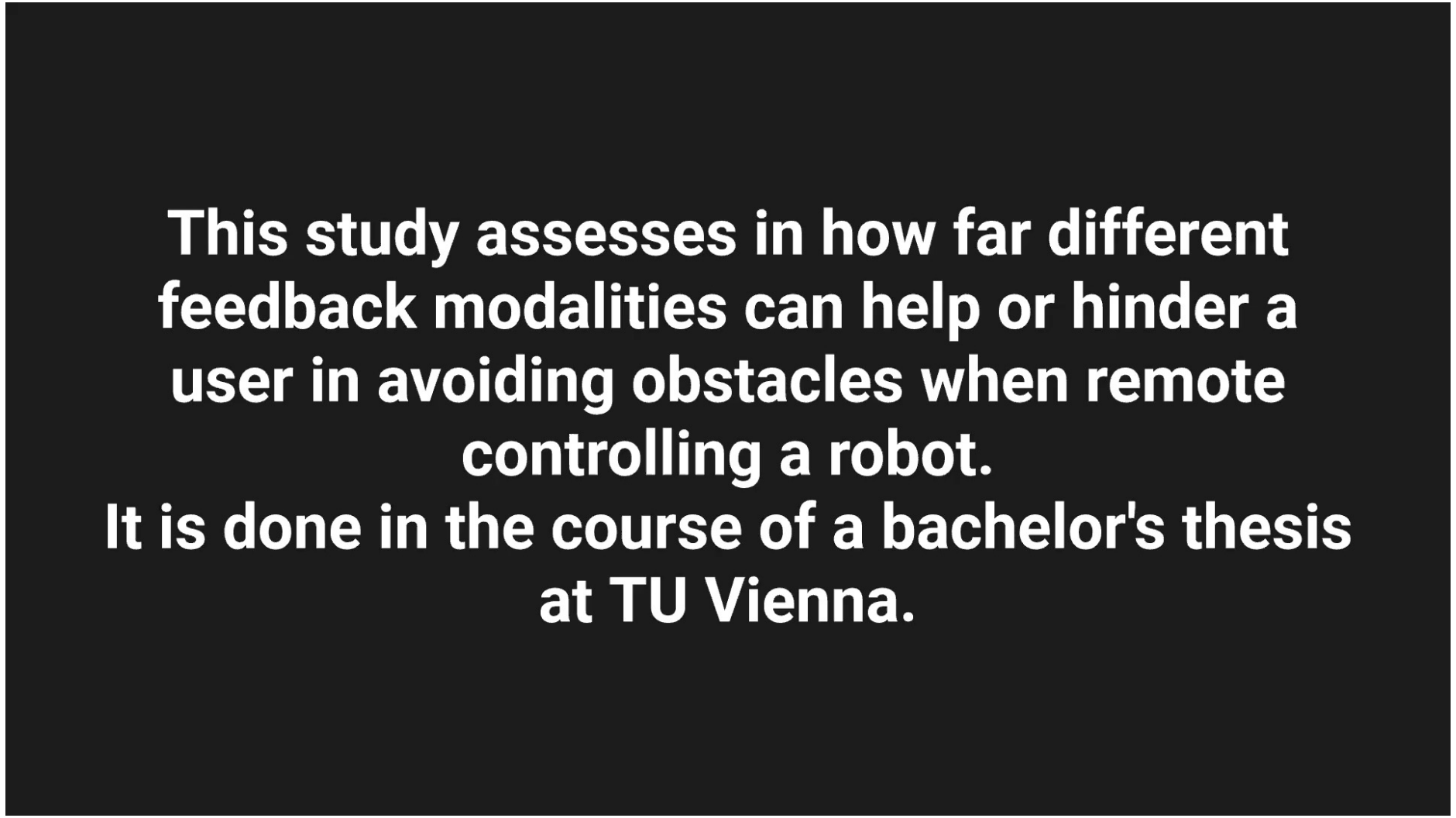
Khaled Kassem, Tobias Ungerböck, Philipp Wintersberger, and Florian Michahelles. 2022. What Is Happening Behind The Wall? Towards a Better Understanding of a Hidden Robot's Intent By Multimodal Cues. Proc. ACM Hum.-Comput. Interact. 6, MHCI, https://doi.org/10.1145/3546731

Key Takeaways

- Include visual feedback in any form of multimodal feedback
- Auditory feedback is helpful with communicating timing information
- Haptic feedback was divisive, but novel and entertaining
- 3-way multimodal feedback less cognitively loading than single modalities
  → suitable for visually obstructed collocated collaboration in VR

Khaled Kassem, Tobias Ungerböck, Philipp Wintersberger, and Florian Michahelles. 2022. What Is Happening Behind The Wall? Towards a Better Understanding of a Hidden Robot's Intent By Multimodal Cues. Proc. ACM Hum.-Comput. Interact. 6, MHCI, https://doi.org/10.1145/3546731

Increasing of throughput




Driving Functions
Cruising Functions
Maneuvering Functions
80

https://www.waffenradforums.net/uploads/editor/df/ynbvibmraa4d.jpg

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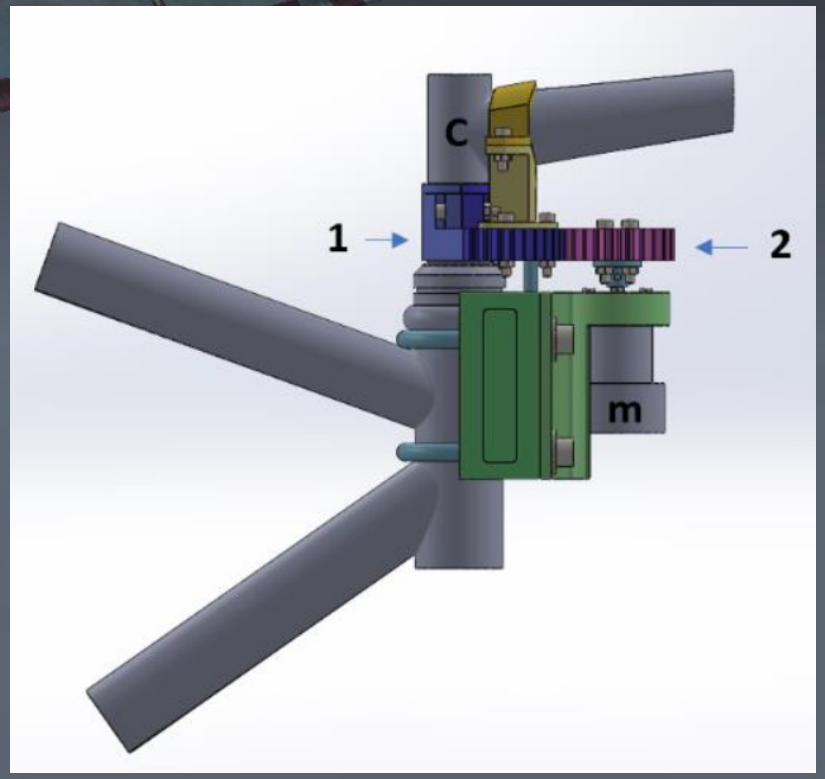
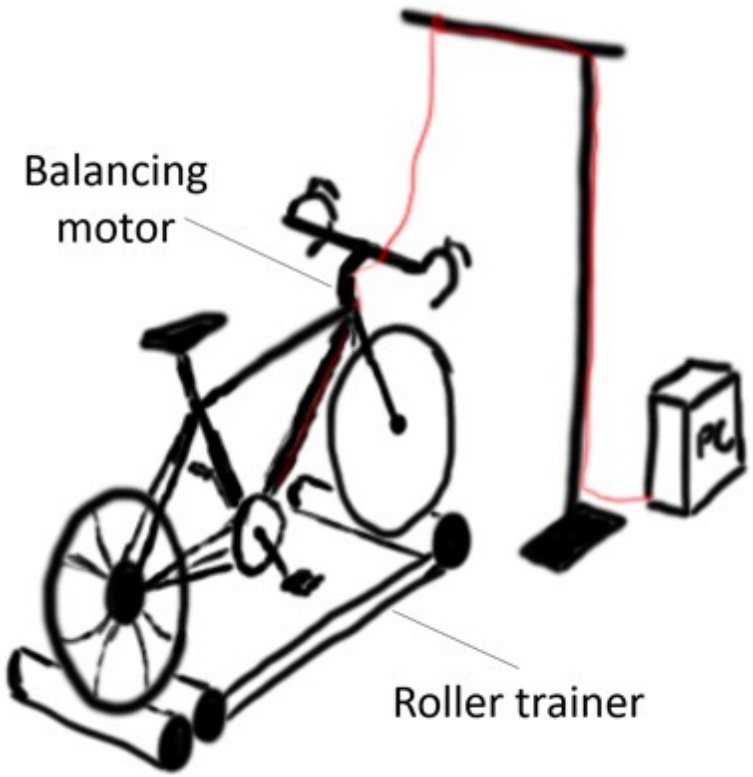
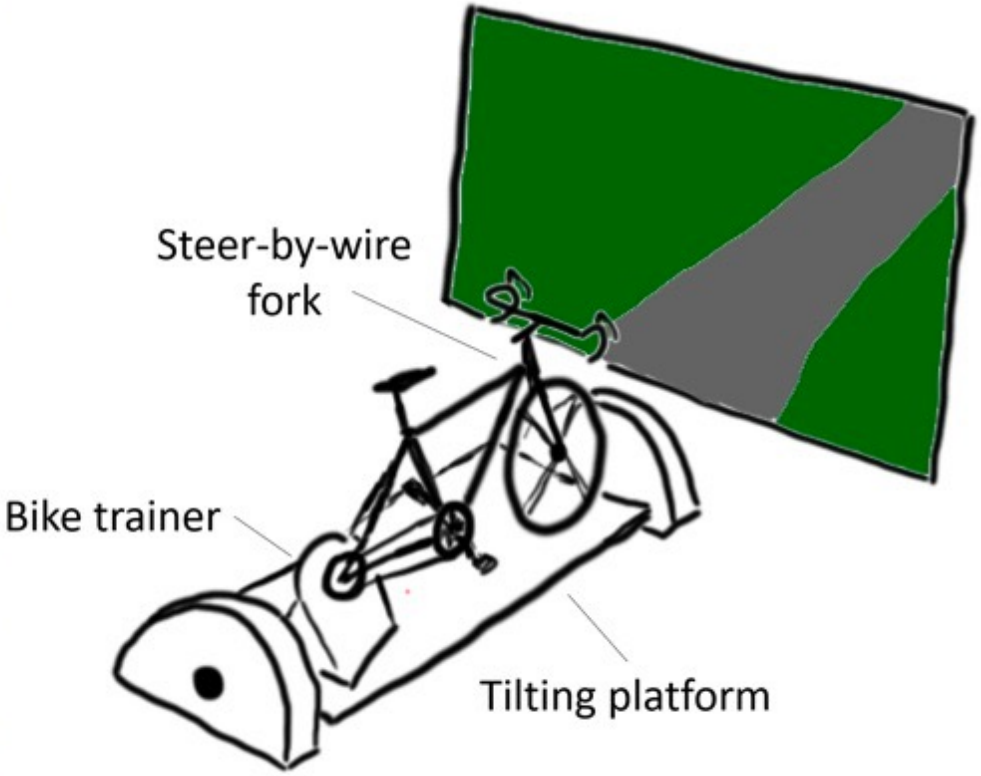
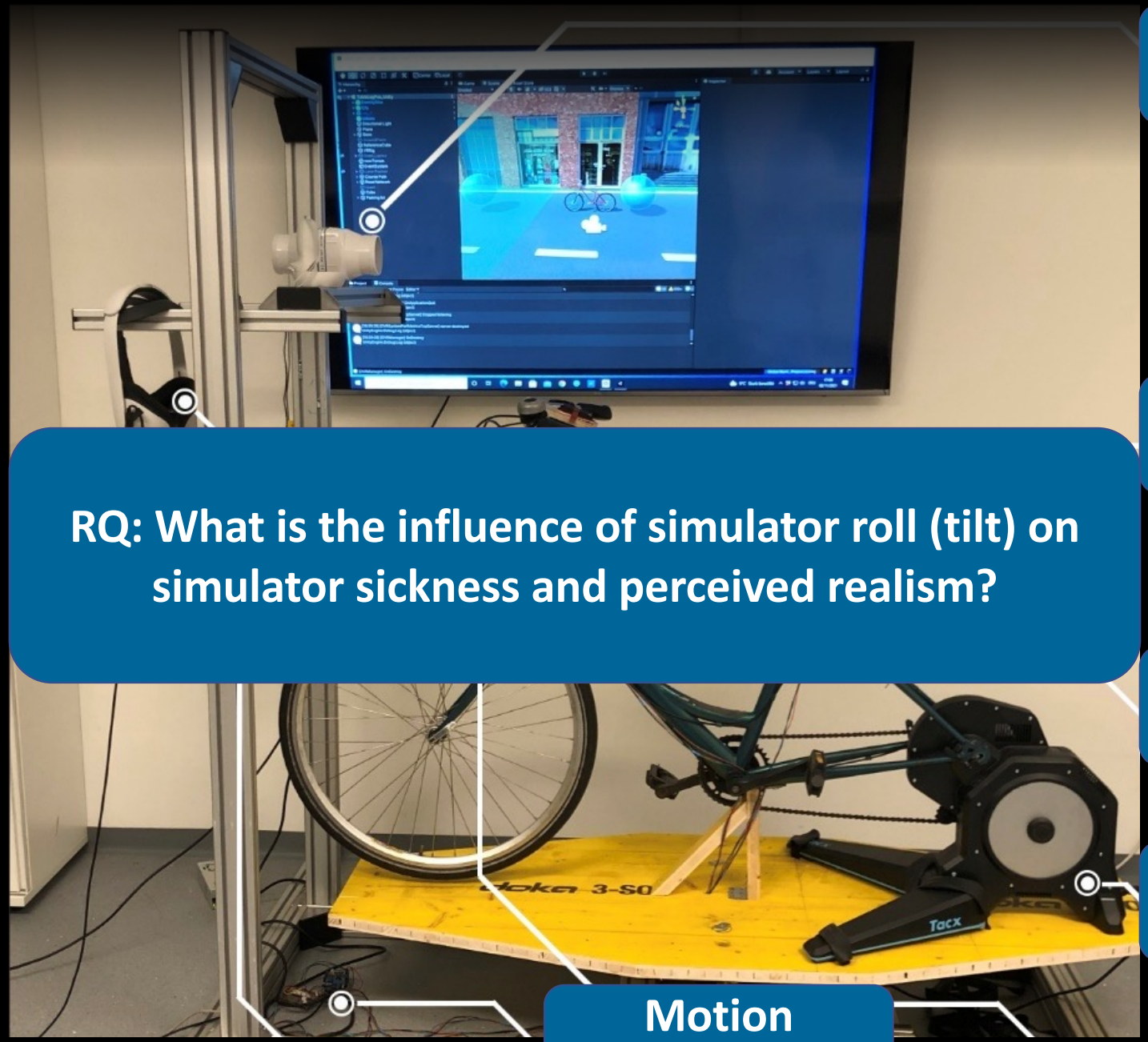

C
1
2
m

Test environment: bicycle simulator





Simulator Design



Airstream

Steering Motor

RQ: What is the influence of simulator roll (tilt) on simulator sickness and perceived realism?

Pressure Sensor Brakes

Tacx Flux 2 Smart Trainer

Motion Platform

Philipp Wintersberger, Andrii Matviienko, Andreas Schweidler, and Florian Michahelles. 2022. Development and Evaluation of a Motion-based VR Bicycle Simulator. MobileHCI 2022, https://doi.org/10.1145/3546745

User study

- 3 Conditions (no support, strong tilt, weak tilt)
- Within-subjects design, N=31 (21 male, 10 female)
- Test track with different curve elements (5, 10, 15m radius)
- Measurements
  - Ingroup Presence Questionnaire (IPQ)
  - Simulator Sickness Questionnaire (SSQ)
  - User Experience Questionnaire (UEQ)
  - Driving Performance (SDLP, speed, steering angles)

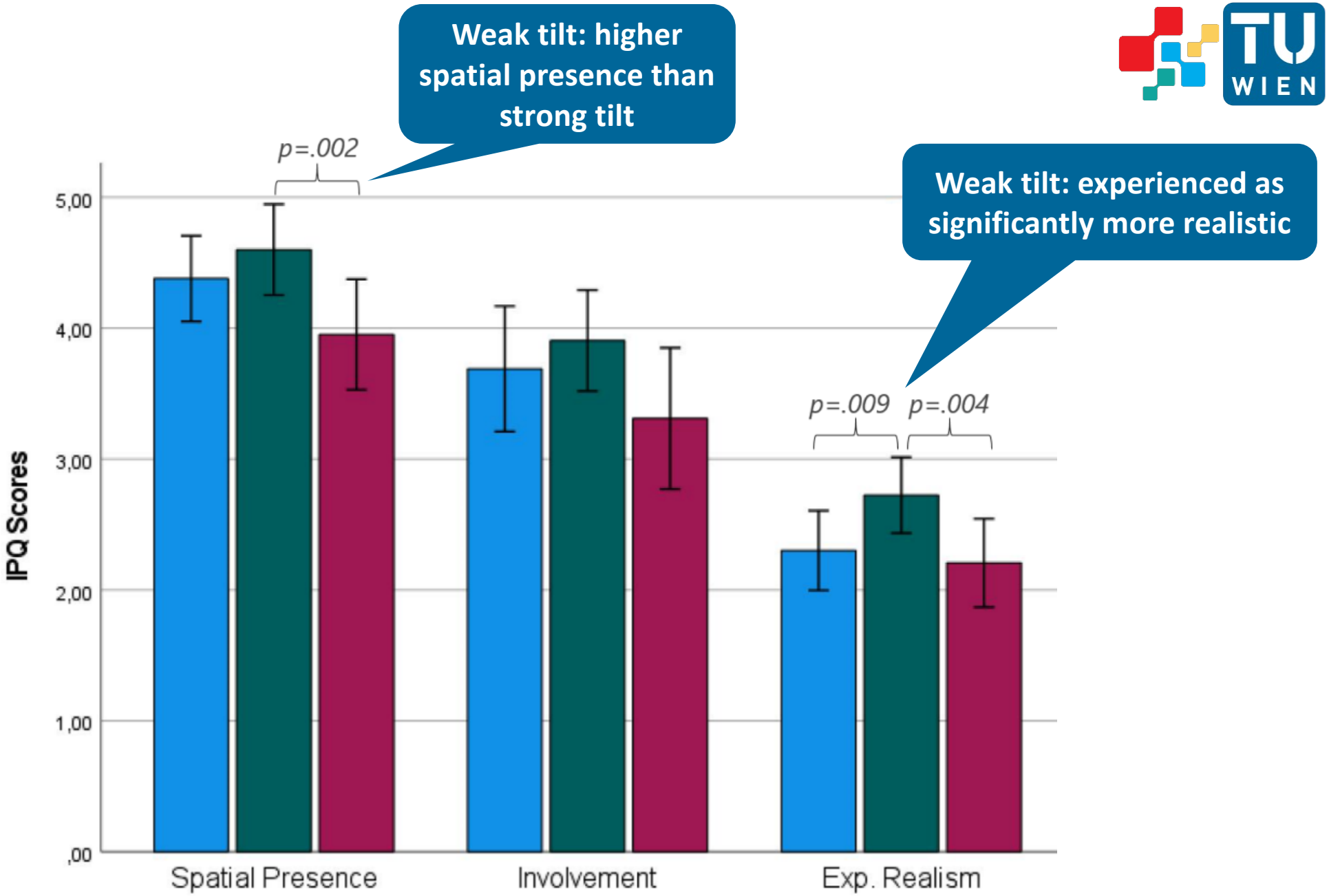

TableLogPos_Unity - TableLogPos_Unity - PC, Mac & Linux Standalone - Unity 2020.3.16f1 Personal <DX11>
File Edit Assets GameObject Component Oculus Scenes Uduino Window Help
Hierarchy
TableLogPos_Unity
EternityBike
City
Uduino
Directional Light
Plane
Base
ReferenceCube
VRRig
newTerrain
EventSystem
Course Path
Road Network
Quad
Cube
Parking lot
Game
Scene
Asset Store
Display 1
Free Aspect
Left Eye
Inspector
Mesh Renderer
Materials
Lighting
Cast Shadows
Receive Shadows
Probes
Light Probes
Reflection Probes
Anchor Override
Additional Settings
Platform (Script)
Steering Angle
Roll Position
Pitch Position
Bike Speed
Previous Bike Speed
Delta Bike Speed
I Steering Angle
I Tilt Angle
Optimized I Tilt Angle Factor
Calculated Tilt Angle
Gravitational Acceleration
I Curve Radius
Supported Angle
Sign
Support Factor
Speed Calculation Multiplier
Speed Calculation Exponent
Roll Multiplier
Support Level
Bicycle
Blue Material (Material)
Shader
Standard
Add Component
Zur Suche Text hier eingeben

Results

Baseline

Weak Tilt

Strong Tilt



https://upload.wikimedia.org/wikipedia/commons/8/8a/Statue_of_Pheidippides_along_the_Marathon_Road.jpg

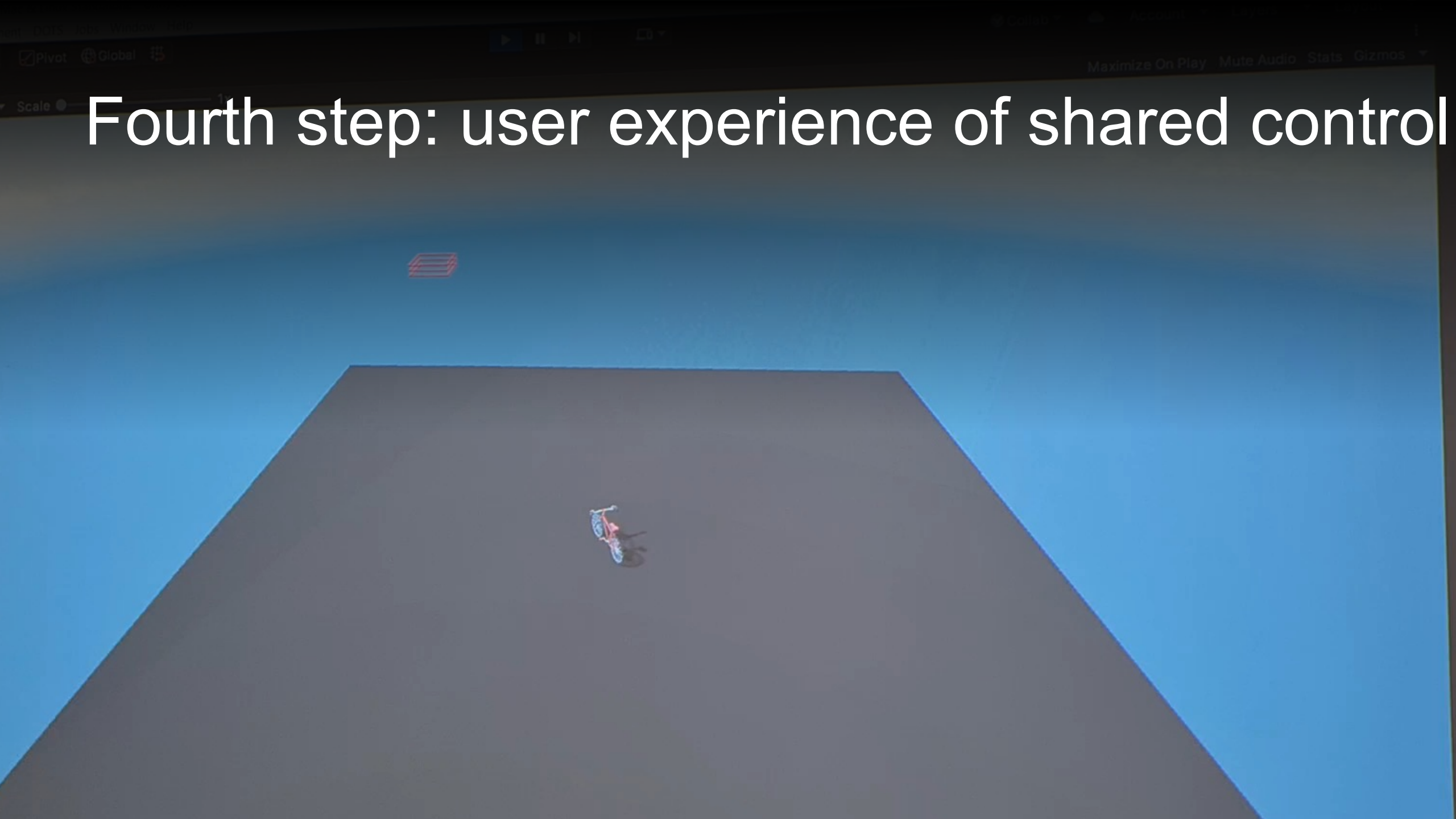
VR Bicycle Simulator
Summary and Conclusion

- „Construction Manual“ for a motion-based VR bicycle simulator
- Strong „realistic“ tilt is unsuitable for VR cycling
- „Weak“ tilt improves immersion and presence while not inducing additional simulator sickness, i.e., „the right amount of realism“
- A „sweet spot“ for the tilt function must be determined (sickness vs. Realism)
- We need more systematic research on „simulator fidelity“ for bike simulators!

[1] R. Parasuraman and V. Riley, Humans and automation: Use, misuse, disuse, abuse, Human factors, vol. 39, no. 2, pp. 230253, 1997..

Philipp Wintersberger, Andrii Matviienko, Andreas Schweidler, and Florian Michahelles. 2022. Development and Evaluation of a Motion-based VR Bicycle Simulator. MobileHCI 2022, https://doi.org/10.1145/3546745

Fourth step: user experience of shared control



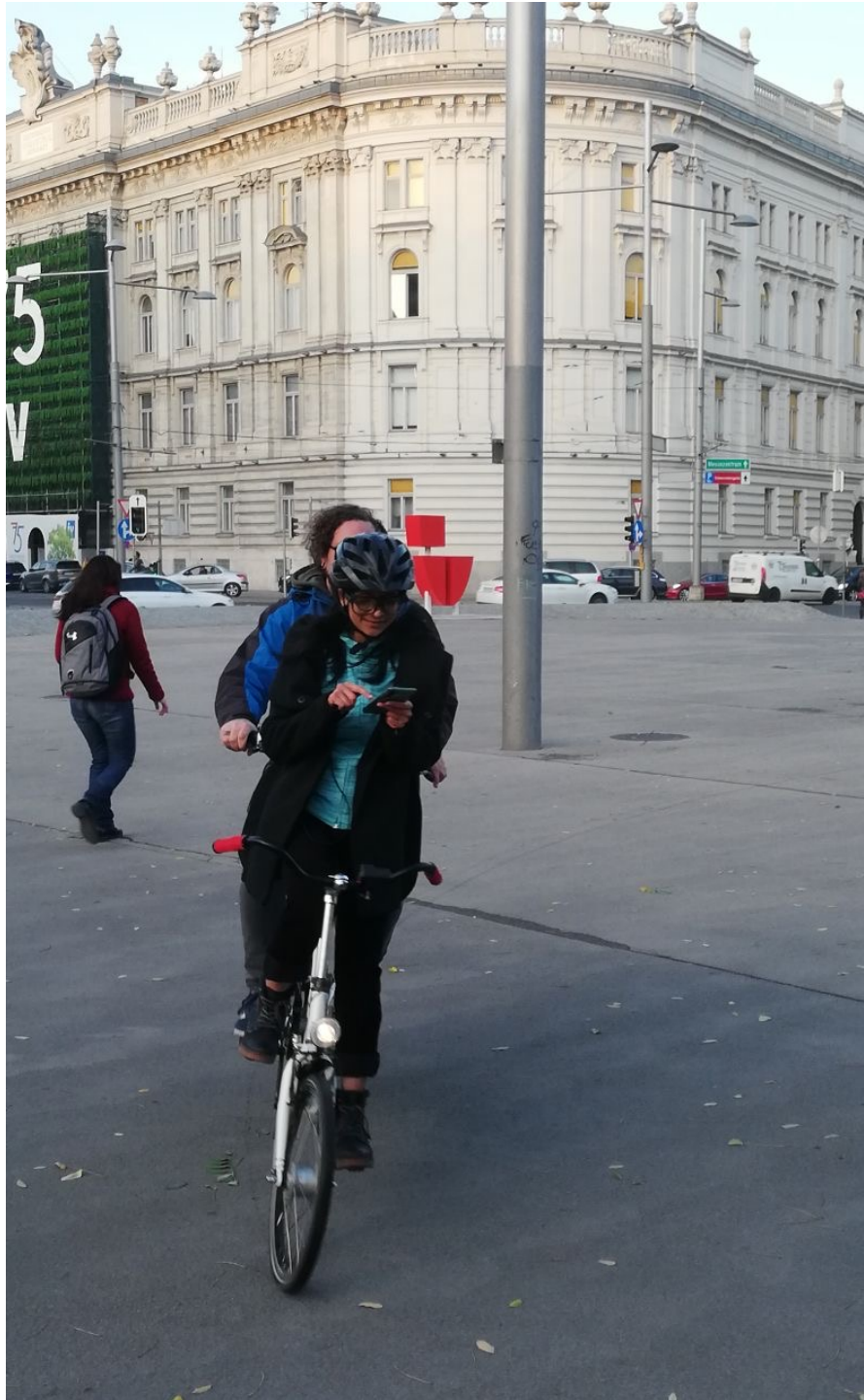
„Wizard of Oz“ study

- Parent-Child Tandem, both riders can
  - Steer,
  - Pedal, and freewheel independently
- Experimenter in the back mimics the self-balancing bike and announced upcoming turns verbally

User Study
Participants & Measurements

- N=13
  - 10 male, 3 female
  - Age = 25.7 (22-35 years)
  - 6 frequent cyclists (use bike at least 4 times/week)
  - 7 infrequent cyclists

- Measurements
  - Thematic Analysis: Interviews and think-aloud
  - Hands on/off: camera facing upper body
  - Monitoring behavior: Eye Tracker

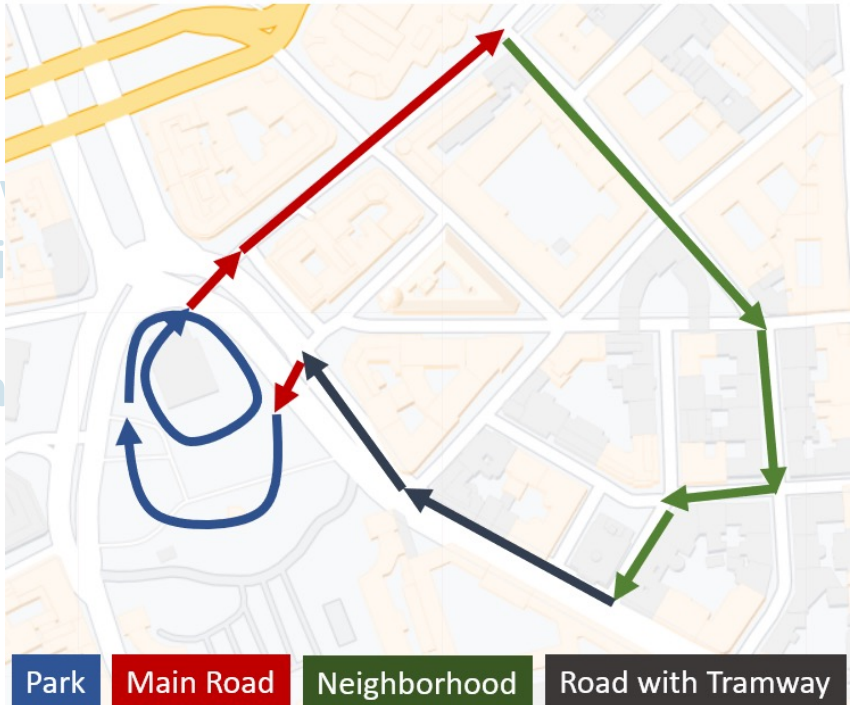


User Study
Participa

› N=13
  › 10 ma
  › Age =
  › 6 freq
  › 7 infreq

› Measurements
  › Qualitative intervie
  › Camera facing parti
    hands on/off)
  › Eye Tracker to quan
    behavior

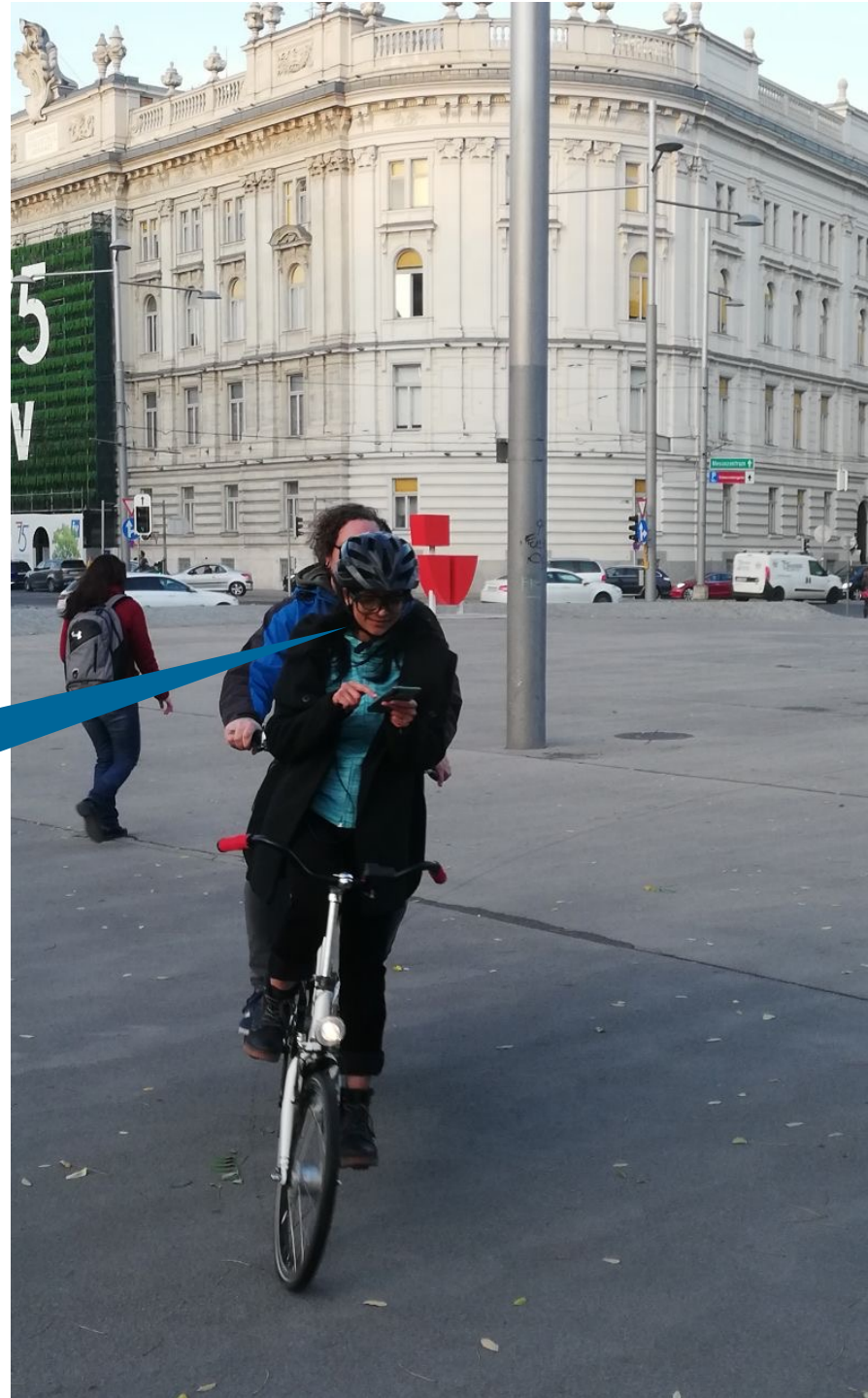
„Please imagine that not the experimenter but a computer system would control the bike with you. You can contribute to pedaling or steering any time, but you can also relinquish control and remove your hands from the handlebar, if you feel safe. During the trip, you will receive text messages on your smartphone. Please answer them only when you feel this is safely possible.“



User Study
Results – Thematic Analysis (5 Key Themes)

- Leisure
  - Especially articulated by frequent cyclists
  - Not a means of transportation, but
  - Tourist attraction for sightseeing
  - Scenic routes
  - Assistance in long bike rides

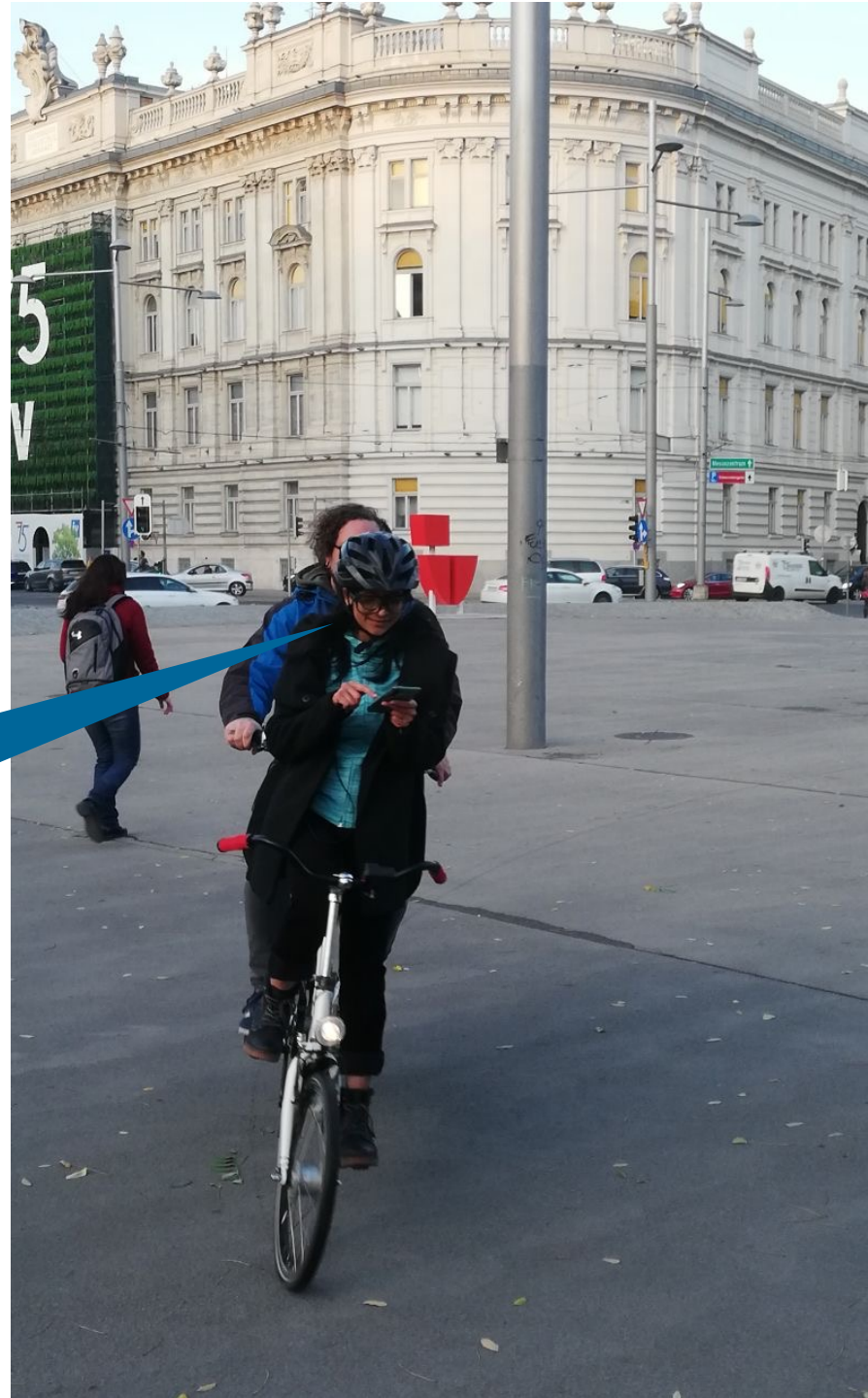
"When I ride long tours, I could imagine using it, but definitely not in the city [...] it is definitely ***very pleasant on tours*** *where you do not have to think for a long time, where you always have to pay attention to the small changes in the steering to just ride without keeping your hands on the handlebars"*



User Study
Results – Thematic Analysis (5 Key Themes)

- Transportation
  - Primarily expressed by infrequent cyclists
  - Urban mode of transportation
  - Learning how to ride a bike
  - Multitasking with smartphones
  - Increased mobility for some target gro

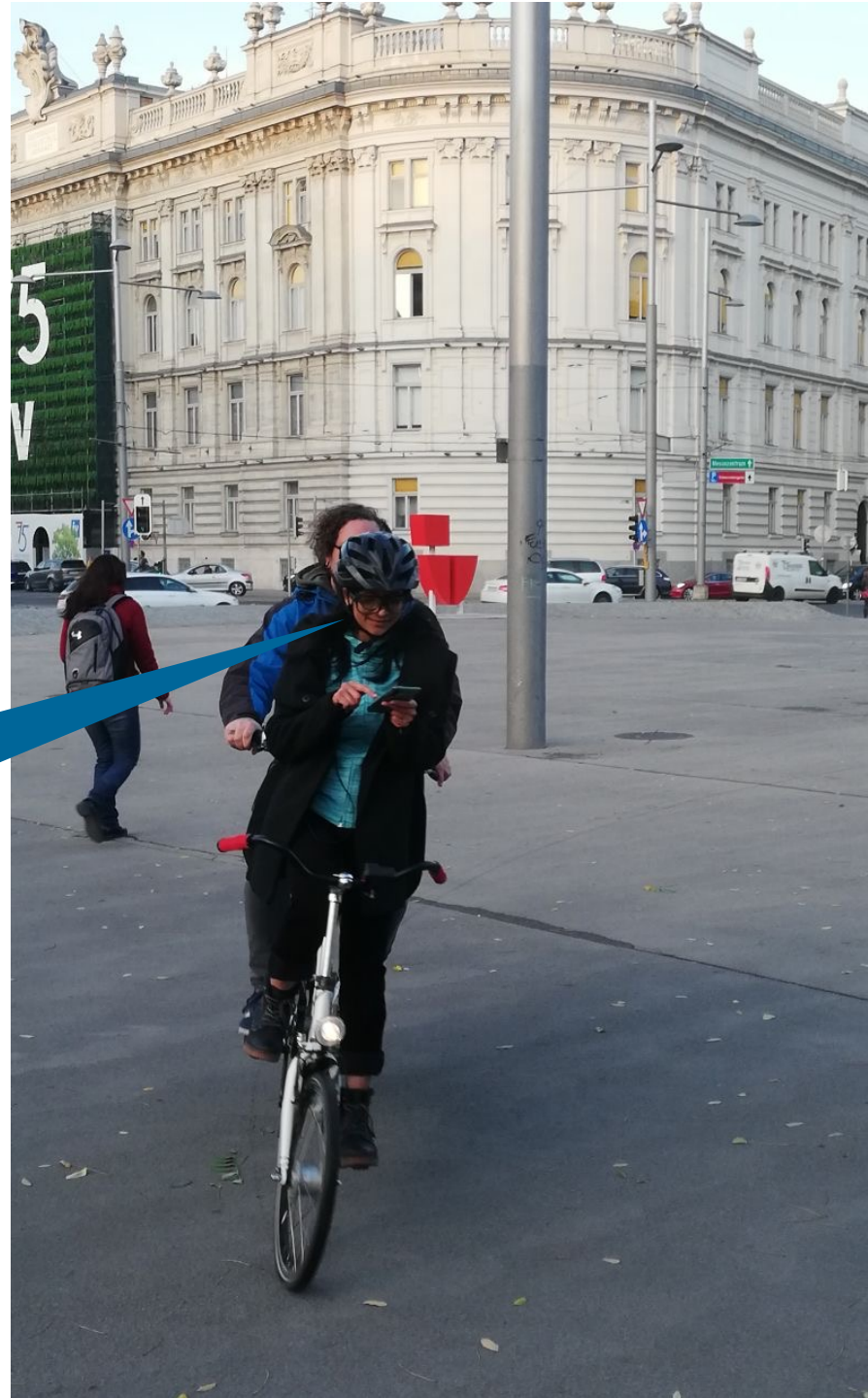
"In the city, if it is possible, it could be ***a quick way to get to places*** *[...] or maybe in the countryside where a bike like this is easier than a cab or something so that it could be helpful in those areas as well"*



User Study
Results – Thematic Analysis (5 Key Themes)

- Trust
  - Cyclists are very vulnerable
  - It would take time to develop trust, even when the system is highly reliable
  - More traffic => less trust

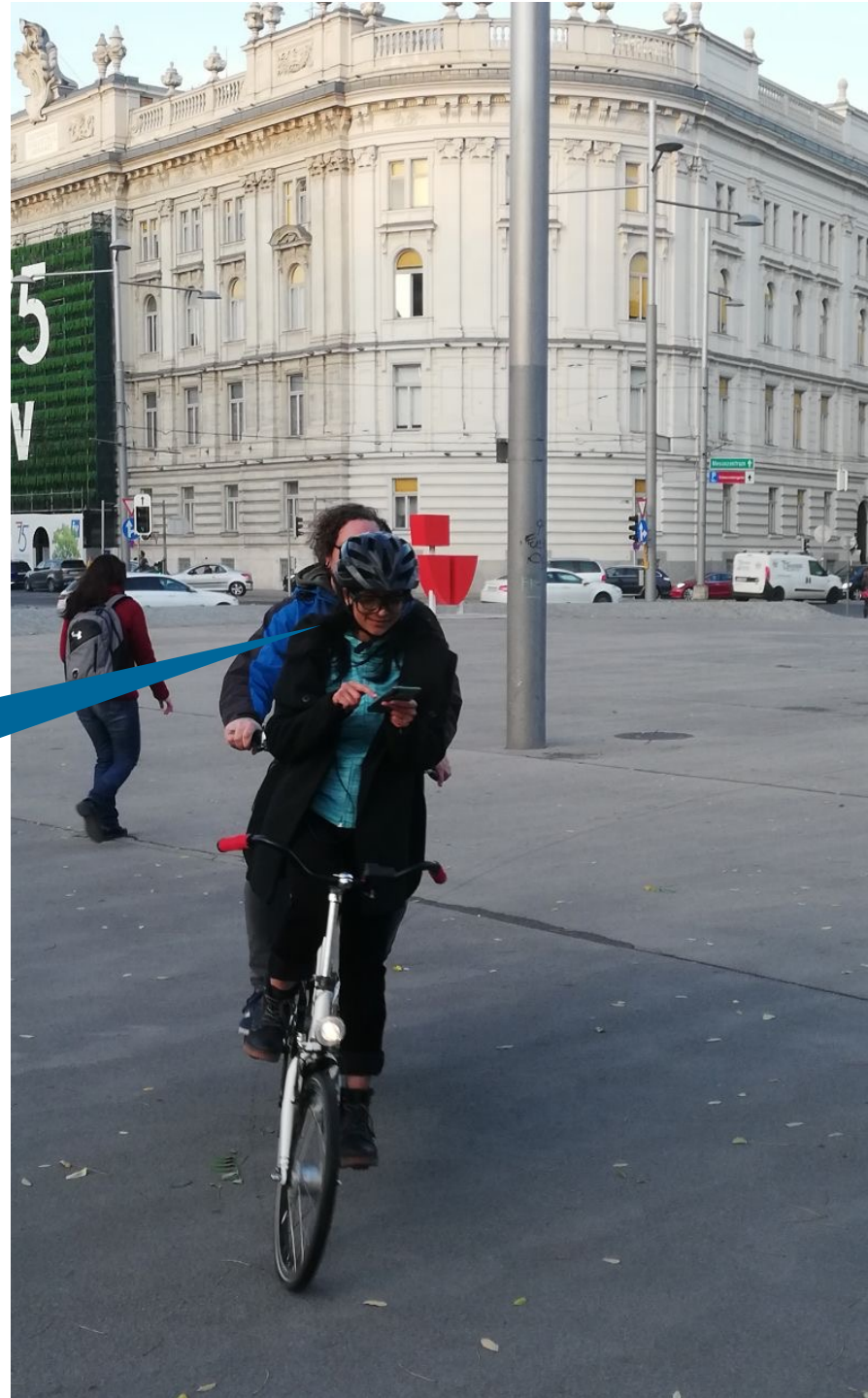
"try it first near a lake or in areas with fewer people to see how the bike behaves [...] ***once I have the confidence, I can use it on the road****, because at the moment if I see a car or a group of people passing very close to me, I am a little afraid that I will collide with them...but once I gain the confidence, I will use it everywhere"*



User Study
Results – Thematic Analysis (5 Key Themes)

- **Transparent Communication**
  - Upcoming actions need to be announced
  - This is not necessarily about trust but motion dynamics
  - Suggestions: auditory and/or visual cues

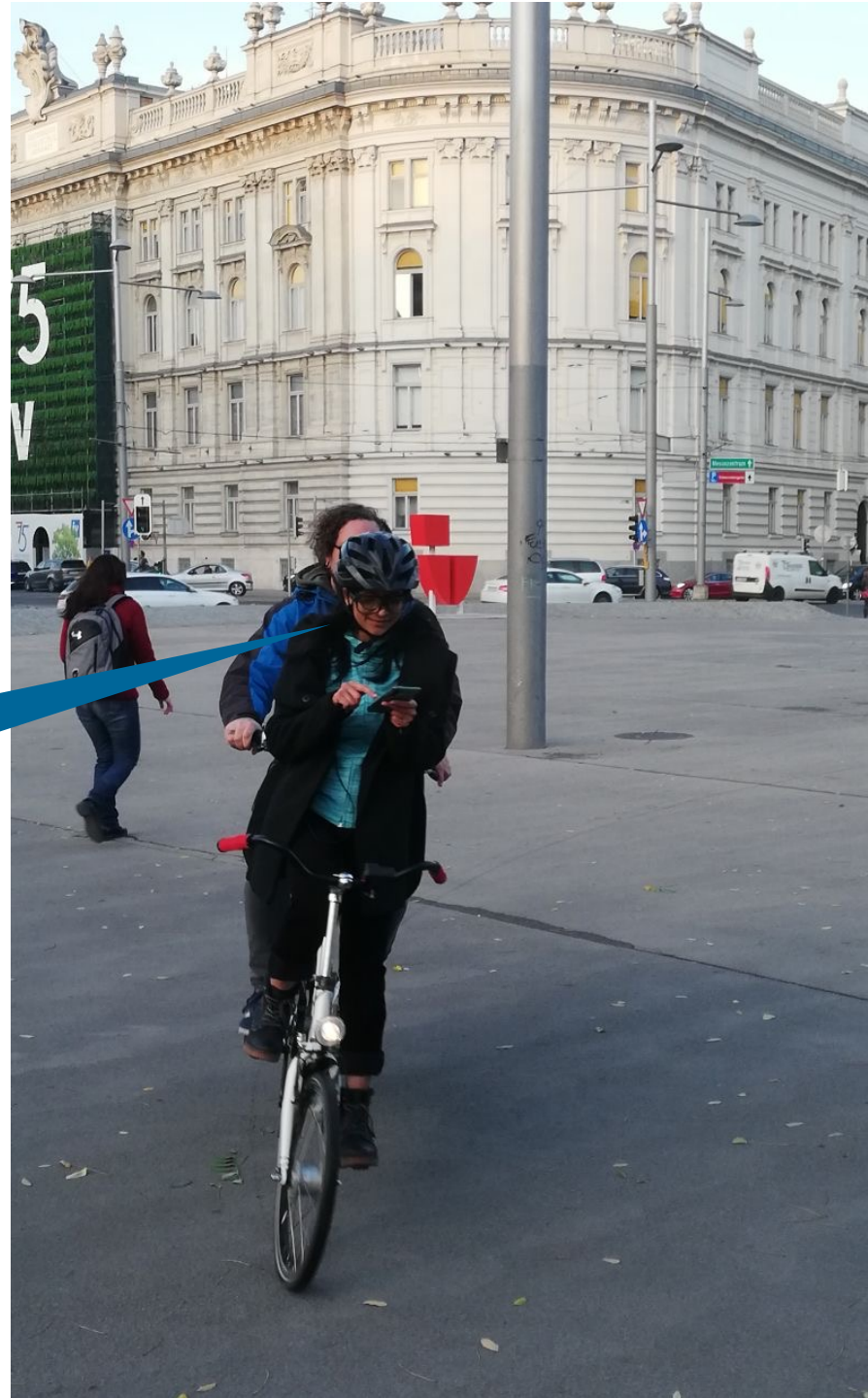
*"It worked kind of well that there were **no abrupt steering** maneuvers. It was good that **it was announced that a turn was coming** now. I think otherwise; it can be irritating or even dangerous."*



User Study
Results – Thematic Analysis (5 Key Themes)

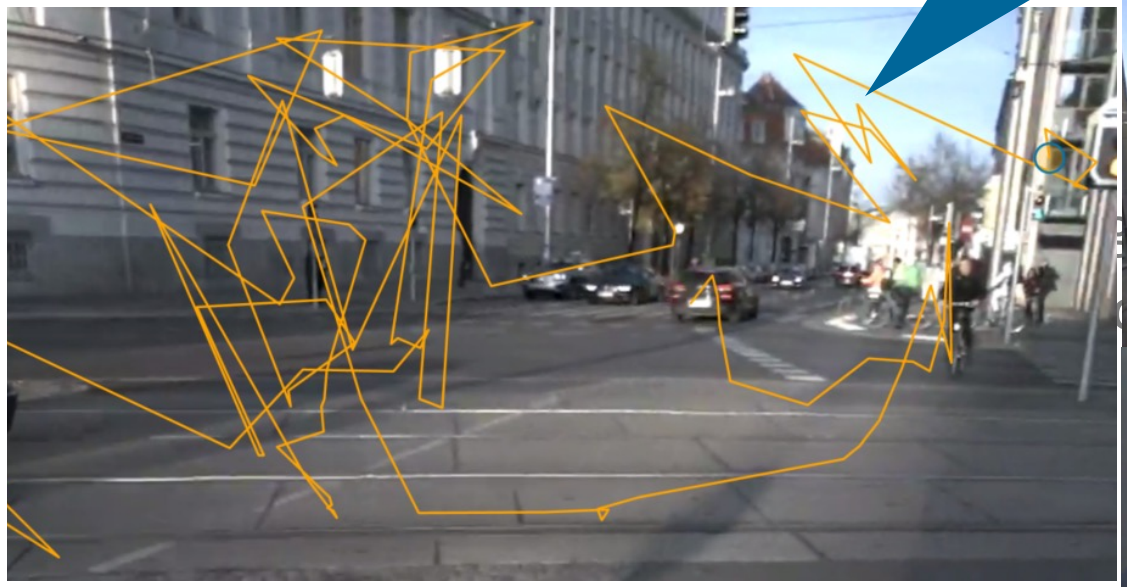
- Intervention
  - Being able to take over control in any situation
  - Not only because of safety but driving style
  - Configuring the bikes „default behavior“

*“when I had to pay attention to the road [...] I found it **difficult that I did not have full control** or I was afraid that the **bike might ride differently** than I expected.”*

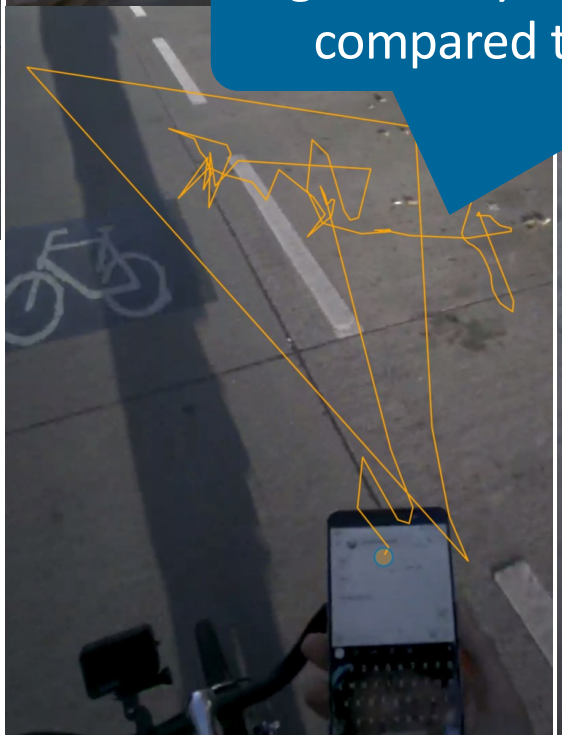


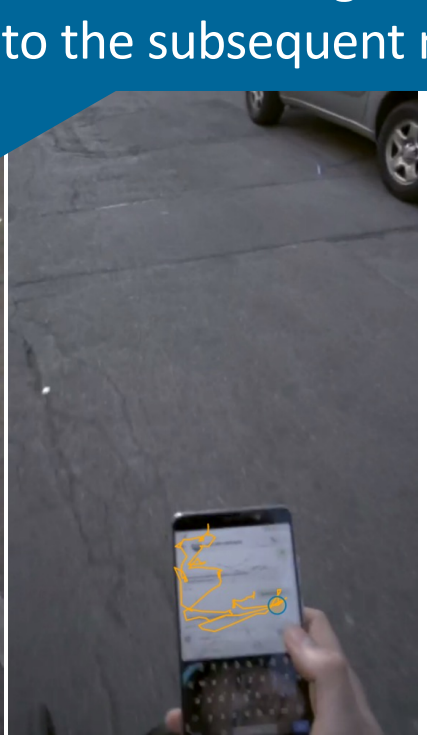
User Study
Results – Gaze Behavior

Highest environment monitoring at junctions, least in the tramway section



Significantly more monitoring during the first, compared to the subsequent messages!





Discussion
Is there a Future for Self-Balancing Bikes?

- Use cases
  - Leisure vs. Transportation
  - Could attract new target groups
  - „Levels of automation“ not applicable to bikes
- Trust and Feedback
  - Feedback is more than information for trust development
  - Complex motion dynamics must be considered
- Monitoring and Behavior
  - Overreliance must be expected
  - In general, consistent with manual bike studies

Self-Balancing Bicycles
Summary

- Self-Balancing bikes could **expand the user base** and **complement existing services**
- **Frequent cyclists** see less benefit, would **use it for tourism or long bike tours**
- **Trust is a major concept** for bicycles, too
- **Multitasking** can become a source of **overtrust** when using self-balancing bikes
- **Fine-grained feedback** is necessary to allow users adjusting their body positions

[Philipp Wintersberger, Ambika Shahu, Johanna Reisinger, Fatemeh Alizadeh and Florian Michahelles: *Self-Balancing Bicycles: Qualitative Assessment and Gaze Behavior Evaluation*, MUM2022]

What’s next…making better decisions?

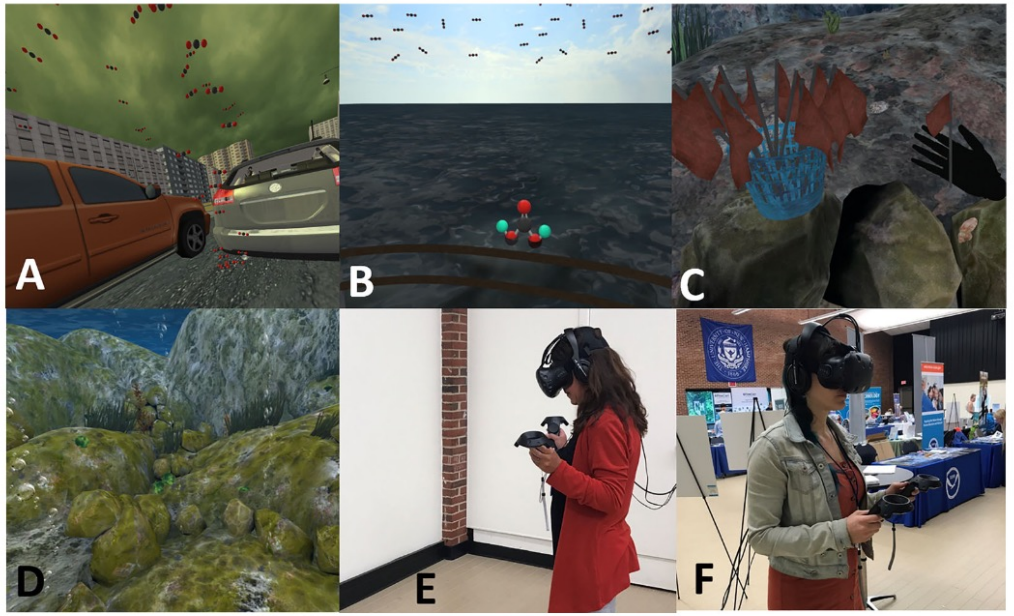


Figure 2. A: CO_2 molecules spewing out of a car. B: CO_2 reacting with sea. C: Participant placing flags next to the sea snails on the reef. D: Acidified reef without sea snails. E, F: Consultation participants in VR.

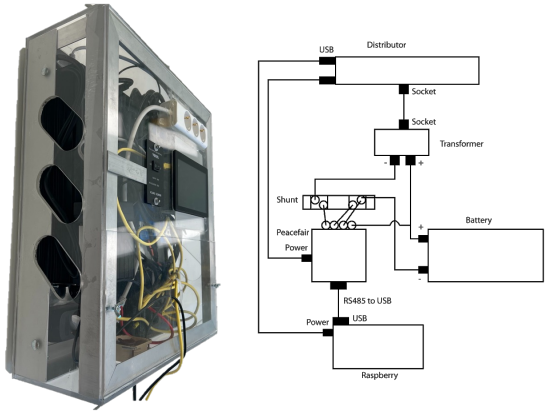
Géraldine Fauville, Anna C. M. Queiroz, Linda Hambrick, Bryan A. Brown & Jeremy N. Bailenson (2021) Participatory research on using virtual reality to teach ocean acidification: a study in the marine education community, Environmental Education Research, 27:2, 254-278, DOI: 10.1080/13504622.2020.1803797

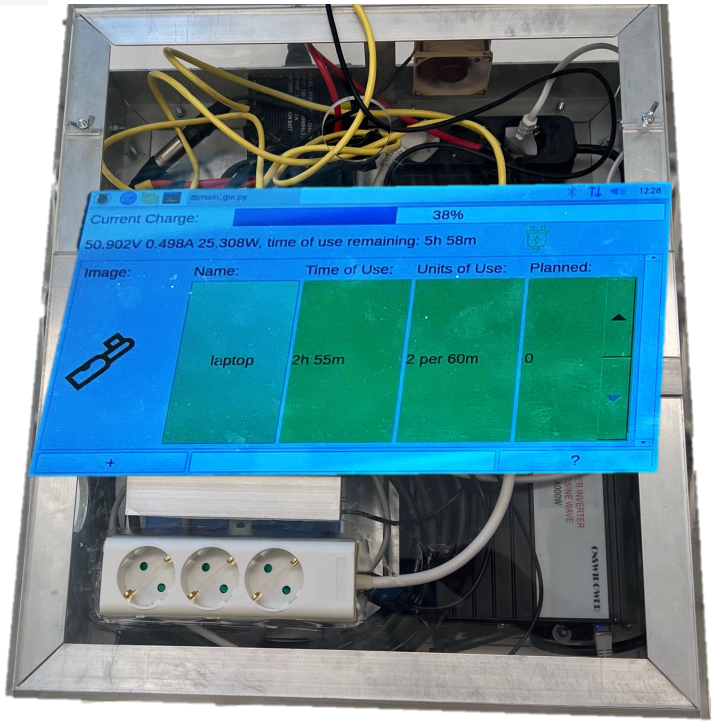
Achieve your goals

- How to complement human deficiencies by technologies?
  - How to help people to better achieve their goals?
  - How to support long-term thinking?
  - How to keep the human in control?

Understanding of resources

Source: https://carbon.kilowh.at/





Multiplication Saves the Day

by BILL MCKIBBEN

Illustration: Corbis

https://orionmagazine.org/article/multiplication-saves-the-day/

CARBON

REBELLION

Are machines the better humans?

- **Machines live up to expectations, but only people can surpass**
- **Machines personalize, but only people can make it personal**
- **Machines thrive in routines, but only people innovate**
- **Machines can predict, but it's still people who surprise**
- **Machines confirm, people smile**

➔Machines thrive with rational tasks, but they can't beat us at creativity, empathy and passion!

➔How can machines and humans achieve more together?

deepdreamgenerator.com "robot helping human"

Summary

machines can level up skills

- augment human performance:
  - perceive, feedback, collaborate, experience
- automating mundane tasks

→ free from tedious repetitive tasks

→ focus much more on communication and innovation

move from information age to creativity age

- Human strengths are **creativity, problem solving, critical thinking, and social collaboration**
- when to hand-over
- seamless interaction and feedback

→ what are the best bridges between human and machine?

Let’s collaborate!

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Thank you!