FRANKFURT UNIVERSITY OF APPLIED SCIENCES

Human-Computer Interaction

Introduction

Welcome

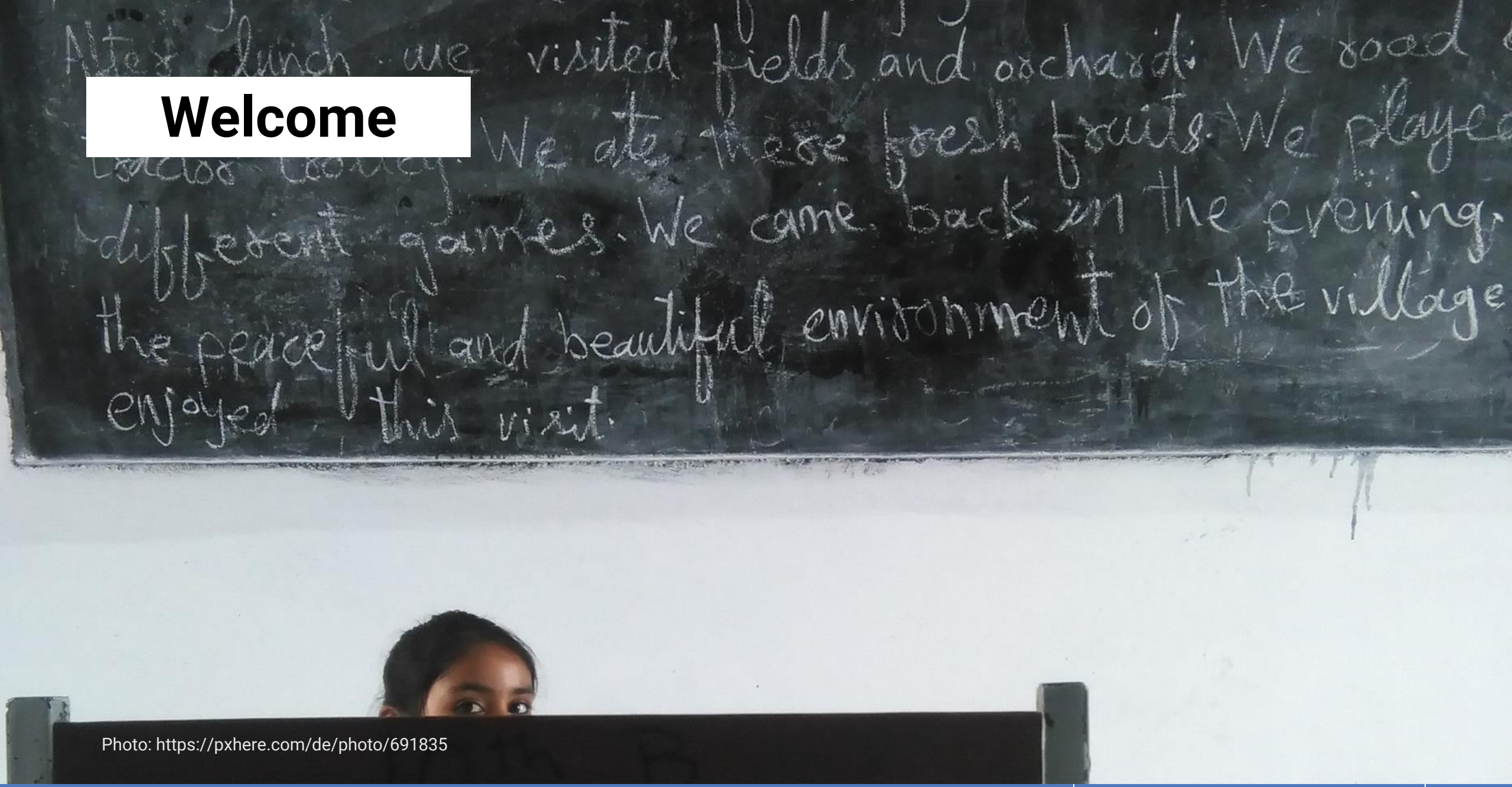

Photo: https://pxhere.com/de/photo/691835

About

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Professor for Human-Computer Interaction

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More information:
www.valentin-schwind.de

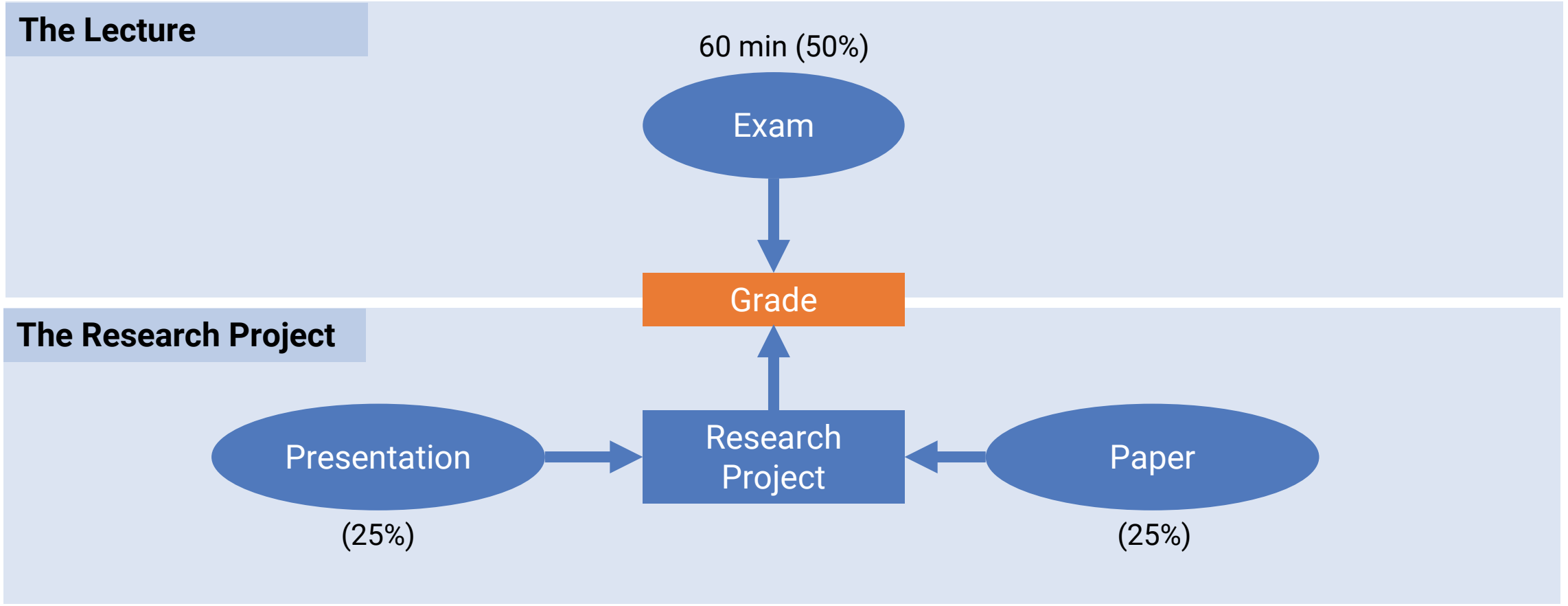
About the Course

- **Compulsory module** (No. 25): Human-Computer Interaction
  - 2 SWS Lecture
  - 2 SWS Exercise
- **Skills: advanced level**, 5th Semester Computer Sciences
  - Module Examination: Portfolio (Project + Exam)
  - Workload: 150 hours in total
- **Recommended prerequisites**:
  - Advanced Programming → “You can develop something”
  - Schlüsselkompetenzen → “You can talk with people”
  - Statistics → “You know what means and standard deviations are”

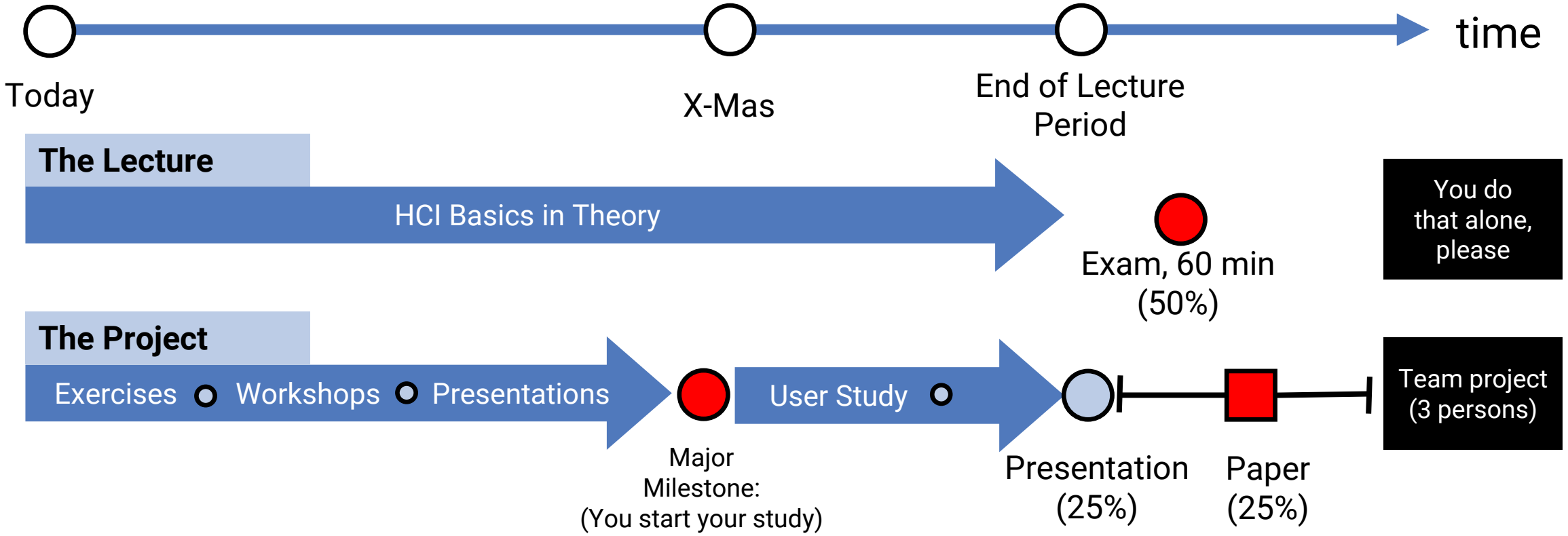
New Moodle: campUAS

- **<ENTER LINK>**
- **<ENTER PASSWORD>**
- **Course material** (slides, papers, videos, etc.) **will be available online**
  - After each block (or some days after)
  - No recordings or live streams

Your Grade

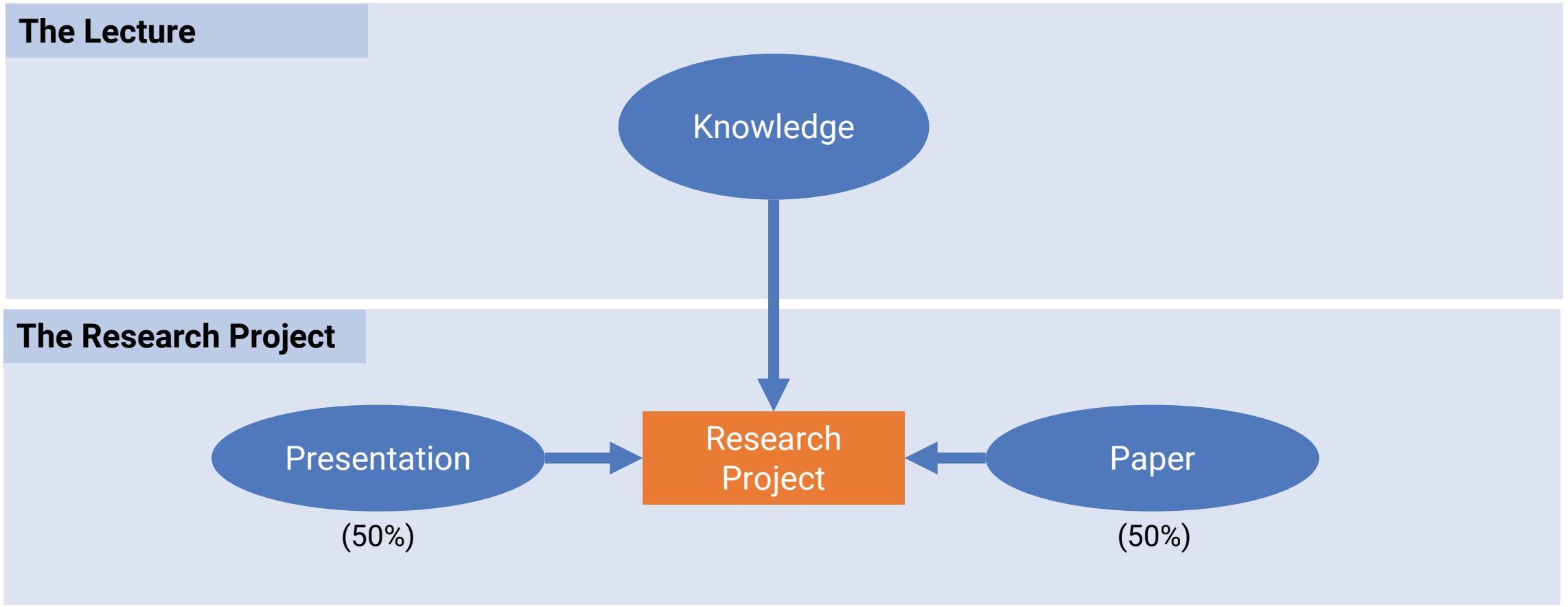

The Lecture
60 min (50%)
Exam
Grade
The Research Project
Presentation
(25%)
Research Project
Paper
(25%)

Semester Plan

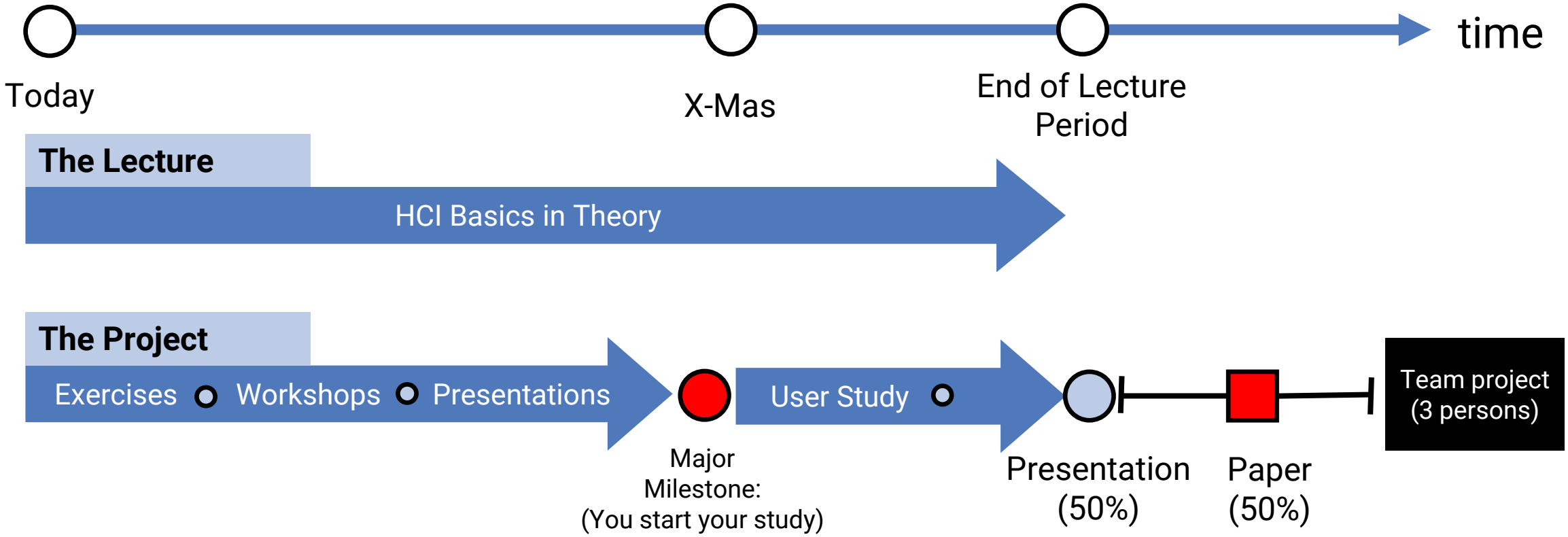


Random feelings

Your Grade


The Lecture
Knowledge
The Research Project
Presentation
(50%)
Research Project
Paper
(50%)

Semester Plan



Week Schedule (Human-Machine Interfaces)

	From	To	Monday	Tuesday	Wednesday	Thursday	Friday
1	08:15	09:45	Lecture	**Human-Machine Interfaces Lecture** (ImA5) 1-129			
2	10:00	11:30					
3	11:45	13:15					
4	14:15	15:45					
5	16:00	17:30	Jessica‘s Thema (Wearables?)	**Human-Machine Interfaces Exercise** (ImA5) 1-252 (Jessica Sehrt)			
6	17:45	19:15					

Week Schedule (Human-Machine Interfaces)

	From	To	Monday	Tuesday	Wednesday	Thursday	Friday
1	08:15	09:45		Games	**Human-Computer Interaction Exercises** (IBIS5A), 1-236	**Human-Computer Interaction Exercises** (IBIS5B), 1-248	Mixed Reality
2	10:00	11:30	Lecture	**Human-Computer Interaction Lecture** (EBIS5/IBIS5) 4-8	**Human-Computer Interaction Exercises** (IBIS5A), 1-236	Mixed Methods	
3	11:45	13:15			**Human-Computer Interaction Exercises** (IBIS5B), 1-236	Intelligent User Interfaces	
4	14:15	15:45				Stefan‘s Thema (3D-Prototyping?)	**Human-Computer Interaction Exercises** (EBIS5), 1-248 (Stefan Resch)
5	16:00	17:30					
6	17:45	19:15					

Week Schedule (Human-Machine Interaction)

	From	To	Monday	Tuesday	Wednesday	Thursday	Friday
1	08:15	09:45					
2	10:00	11:30			Lecture	**Human-Machine Interaction Lecture** (AI/ID1/HIS) 1-234	
3	11:45	13:15			???	**Human-Machine Interaction Exercise** (AI/ID1/HIS) 1-234	
4	14:15	15:45					
5	16:00	17:30					
6	17:45	19:15					

Exercise Planning

- Tuesday 11:45 - 13:15: Questions on Methodologies
- Tuesday 14:15 - 15:45: 3D-Prototyping
- Wednesday 10:00 - 11:30: Experiences in Mixed Reality
- Wednesday 11:45 - 13:15: Mixed Reality and Physiological Sensing

You are free to choose which exercise course you would like to attend!

24 slots per Room!

first comes first serves

After Oct. 21th no changes will be longer possible.

Lecture

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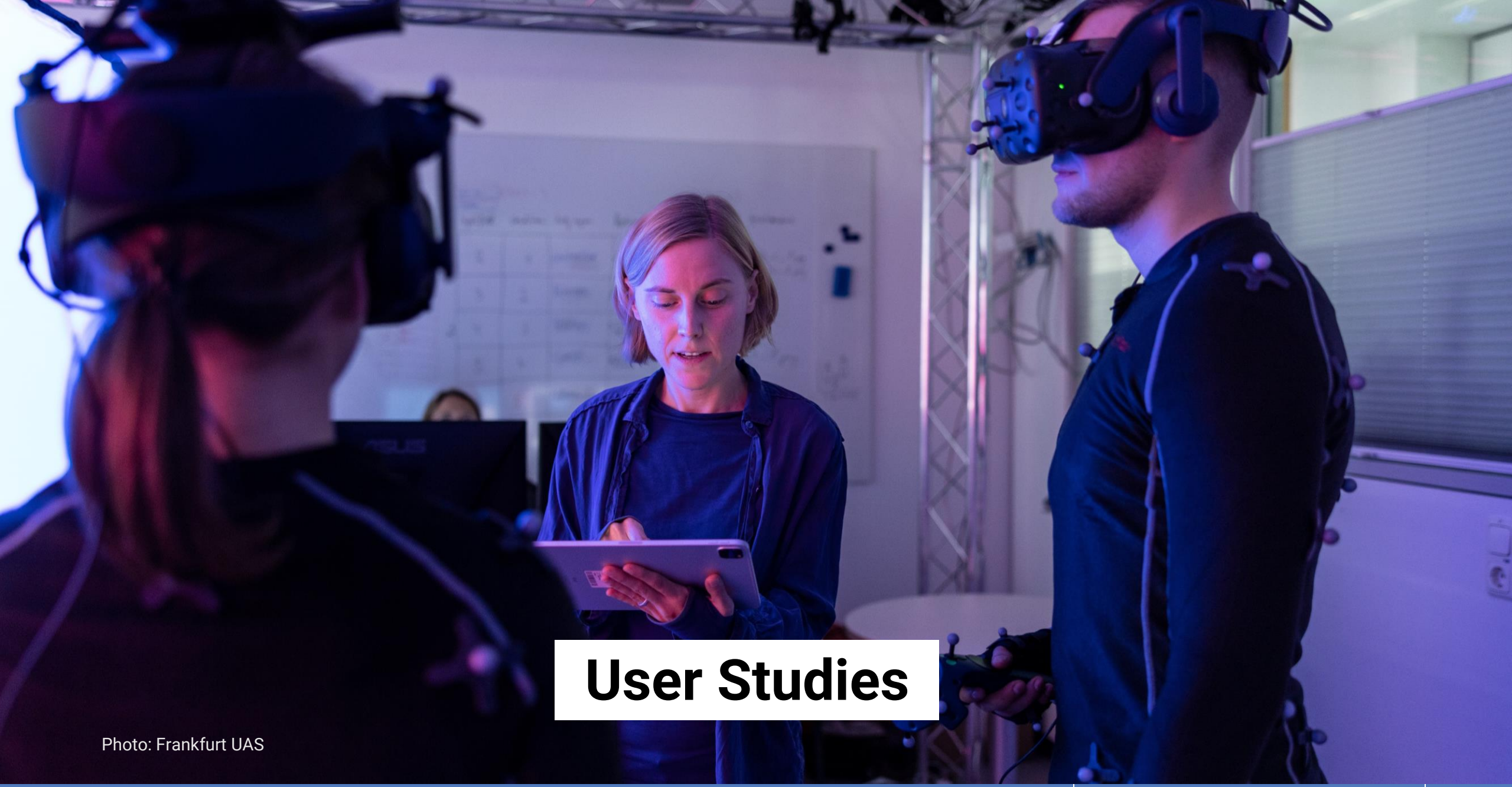


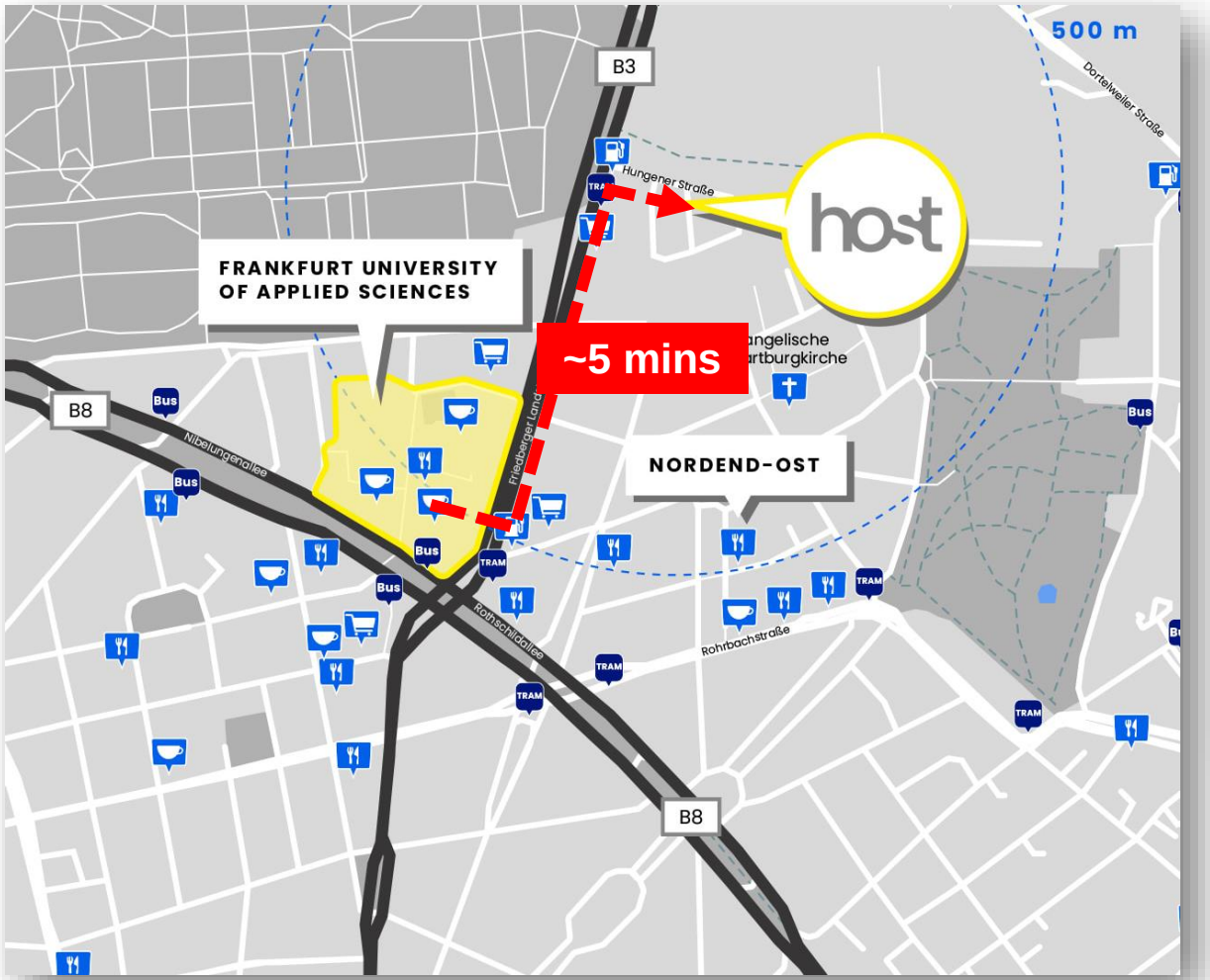
User Studies

Photo: Frankfurt UAS

Research Projects

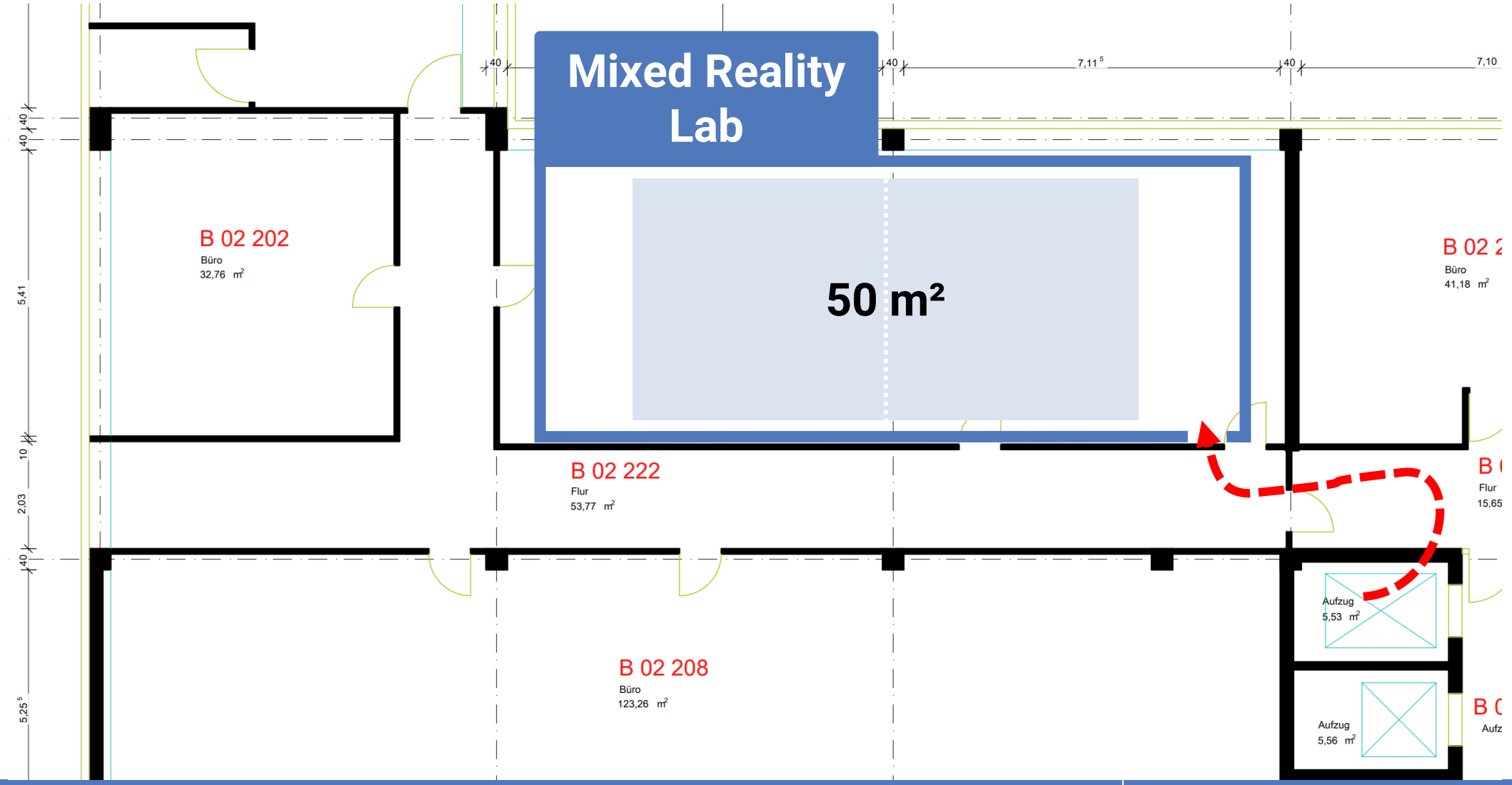
Photo: https://pxhere.com/de/photo/45794 https://pxhere.com/de/photo/754409

The House of Science and Transfer - HoST



https://host-ffm.com
Hungener Str. 6

Our Lab

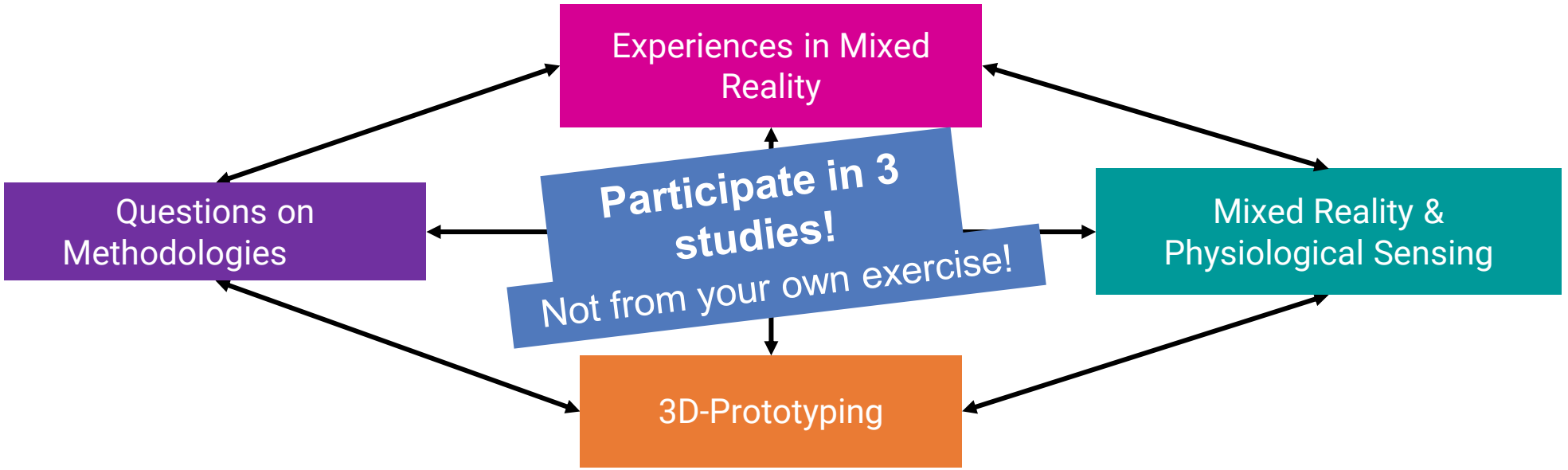

Mixed Reality Lab
50 m²
B 02 202
Büro
32,76 m²
B 02 222
Flur
53,77 m²
B 02 208
Büro
123,26 m²
B 02 2
Büro
41,18 m²
Flur
15,65
Aufzug
5,53 m²
Aufzug
5,56 m²
40
7,11 5
7,10
5,41
10
2,03
5,25 5

Mixed Reality Lab

https://www.frankfurt-university.de/mixed-reality-lab

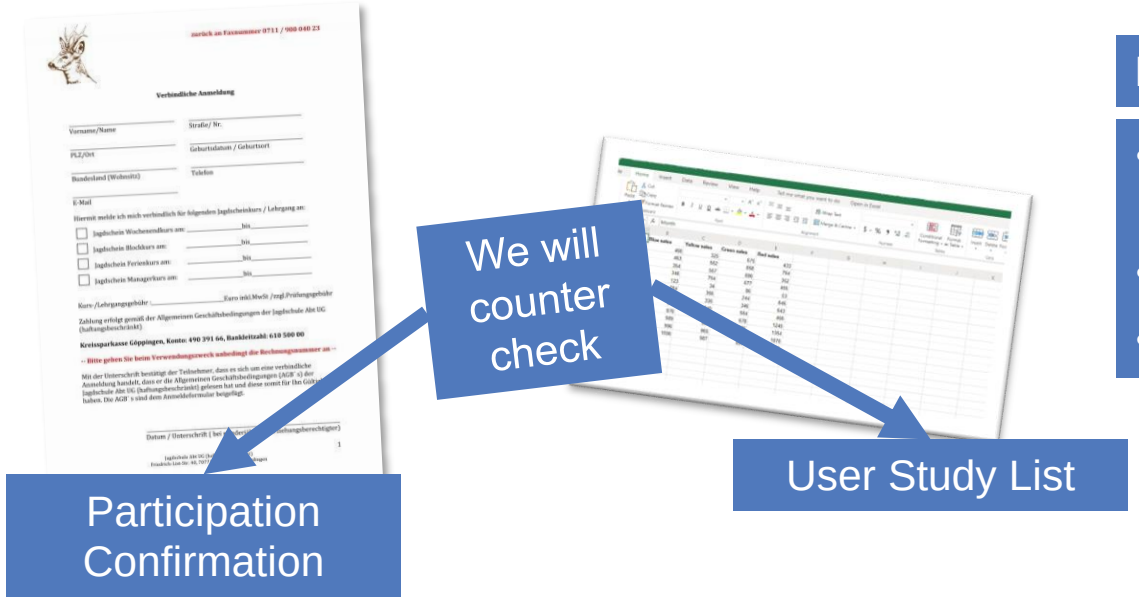
Your are not only experimenter, but also participant!

- Your must participate in **at least three studies** of the other exercises
- Ideally, you do not tell anyone the purpose/procedure of your study



Your Participation

- **Participation is voluntary** (not as in other universities) and you decide in which three studies you want to participate
- However, **this course only works if everyone participates** in user studies!



Not participating in user studies means that

- someone does not participate in your own study and you get no results
- you do not learn how a user study works
- **that we don't like you**

Learning Human-Computer Interaction

Humans

Computers

Photos from PxHere.com/shutterstock.com

Human-Computer Interaction

Interaction? What is interaction?

How can we understand how an interaction works?

Understanding Interactive Systems

- The students **evaluate**, **discuss and present the effects of interactive systems** on users **with empirical methods of HCI** within a team and specified time frame.
  - **you will design**, **conduct** and **evaluate** a user study
  - **you will work in a team**, coordinating and reflecting on difficulties
  - **you will examine** and **provide** feedback on the results documentation
  - **you will deeply analyze** a specific research topic
  - **you will present** the study results and inform other about your findings.
- Goal is that students will be able to **test computer systems for their user experience** and able to examine their usability with quantitative and qualitative research methods
  - Research?

Research – A Definition

- [Research is] "**creative and systematic work undertaken to increase the stock of knowledge**, including knowledge of humans, culture and society, and the use of this stock of knowledge to devise new applications" [1].
- Conducting and presenting the **findings from empirical user studies is essential** in HCI science and evaluation o interactive systems
- **Only new findings or original work** can be published
  - We do not reproduce work that has already been published
- **We aim for original research** (also called "primary research")
  - You conduct a **user study gaining new knowledge**
  - **Sometimes, we conduct secondary research** (reviewing literature) with new findings

[1] UNESCO Definition - Research and development https://stats.oecd.org/glossary/detail.asp?ID=2312

You will…

- … not copy stuff that exist – **why redoing it?**
- … focus on **new systems**
- … not answer **boring research questions** just because it is easy (e.g., who has the better user interface: amazon or ebay?)
- … **implement** (or evaluate) aspects that are only at the core of your research question and evaluation
- … not put too much effort in **developing** something when you can fake it
- … do **a scientific evaluation** (not: “yeah the participants liked our stuff”)
- … **document** your complete progress: **we want text, photos, and videos**!

You will…

- **do empirical user studies** to **answer research questions** that are:
  - strange
  - risky or provocative
  - interesting
  - promising
- **adapt** your concept if necessary
- make use of **your special abilities**
- conduct studies where you **learn something**
- conduct studies where you **don’t know the results**
- learn that **faking, prototyping, and testing** systems is **essential in HCI**

Seminar Classes

- A basic **lecture**
  - Stuff you need to know
- A number of **exercise workshops**
  - Reading & writing HCI papers (yes, you will read papers and write one)
  - How to write a literature review (yes, everyone must look into literature)
    - People who do a literature review do that more extensive
  - How give a good scientific presentation (yes, you must present your stuff)
  - How to use Latex (yes, you will use it)
  - How to use R (yes, you have to do statistics)
  - Designing and conducting **a user study** (yes, you will do one)

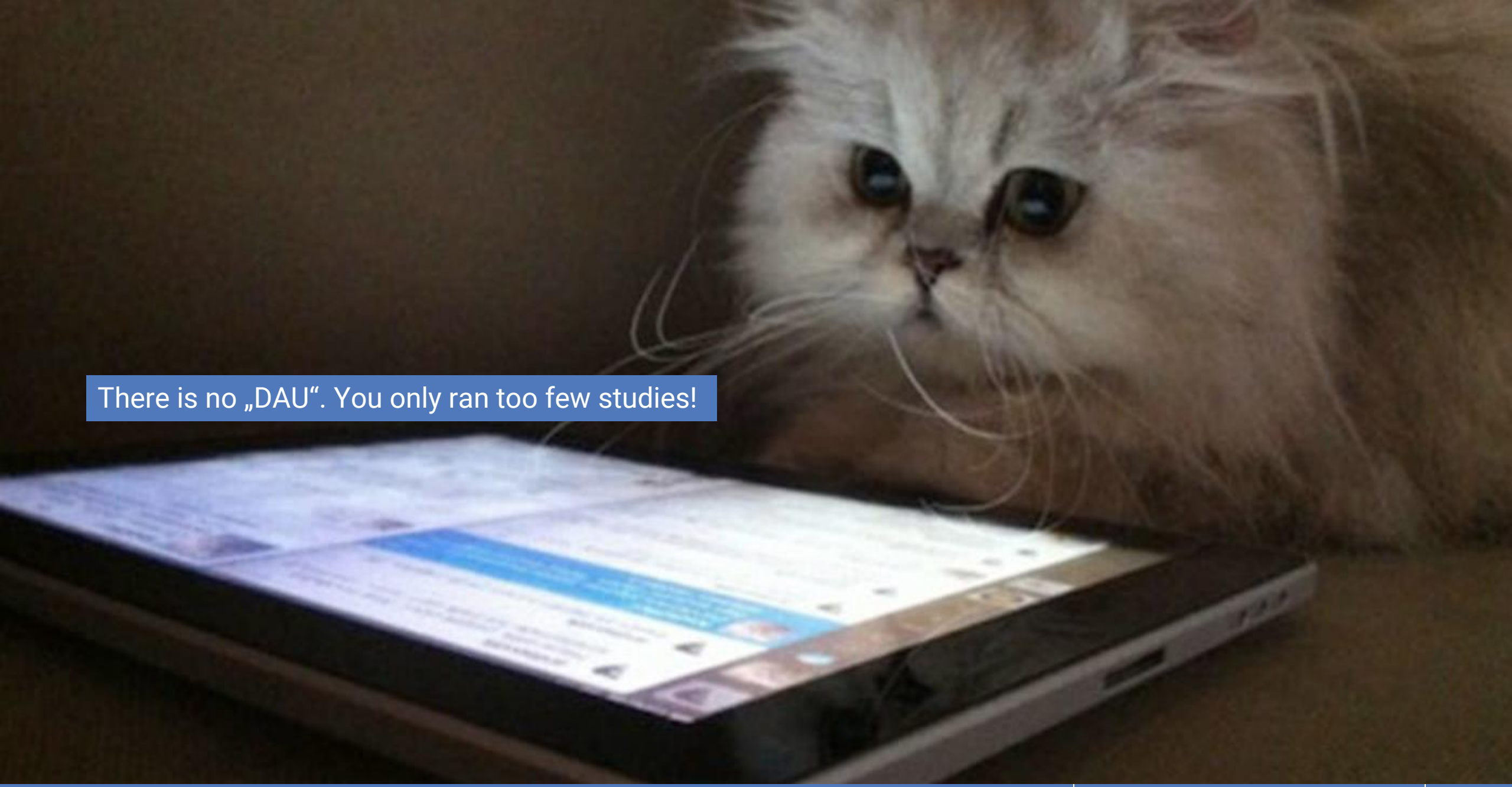
Potential Lecture Content

- Basics
- Users
- Usability
- Perception
- Cognition
- Aesthetics
- Models
- Input
- Output
- Prototyping
- Games
- Accessibility

Recent Streams in HCI

- User Experience and Usability
- Specific Applications Areas
- Learning, Education, and Families
- Interaction Beyond the Individual
- Games and Play
- Privacy and Security
- Visualization
- Health, Accessibility and Aging
- Design
- Building Devices: Hardware, Materials, and Fabrication
- Interacting with Devices: Interaction Techniques & Modalities
- Blending Interaction: Engineering Interactive Systems & Tools
- Understanding People: Theory, Concepts, and Methods
- Critical Computing, Sustainability, and Social Justice
- Computational Interaction

What is the most visited research field in HCI?


There is no „DAU“. You only ran too few studies!

Studies?

- **Studies! There are methods** (we will discuss each method in detail):
  - Prototype testing in a lab study
  - (Web/Mobile) app, websites, downloadable desktop software
  - Field & online surveys
  - Diaries (took probably too long)
  - Expert Interviews (when you can find them)
  - Literature Review (gaining new scientific insights)
- **User Studies? WTF? Do I need to develop something? … Not necessarily …**
  - HCI researchers are smart, they **fake everything** they can…
  - Many prototypes already exist, but nobody has tested them….

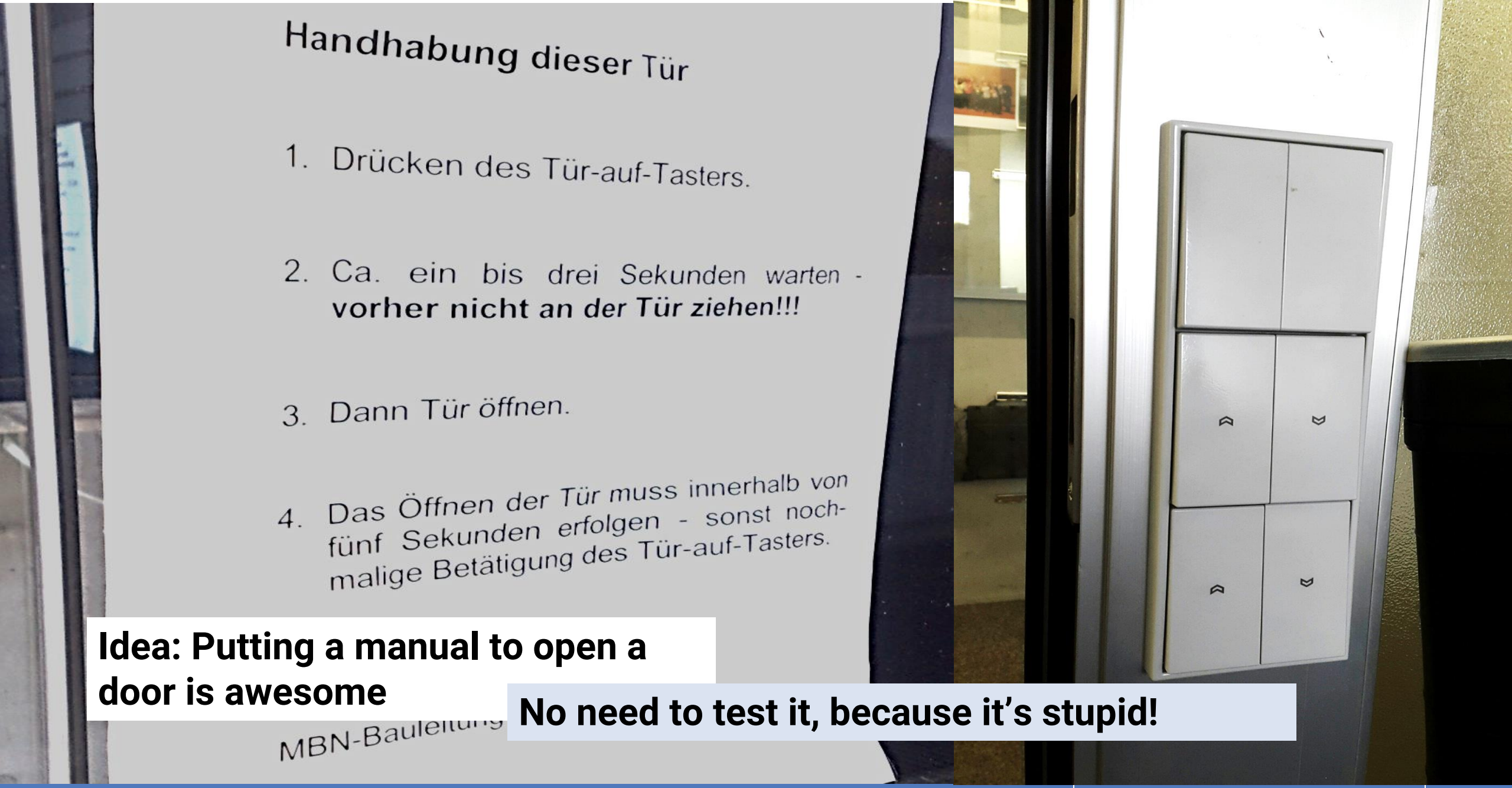
What do you need to evaluate „Alexa?“

„Alexa? Play some music!“

„Here are some songs for you“

Idea: Talking with a computer would be awesome

Test it!



Idea: Putting a manual to open a door is awesome

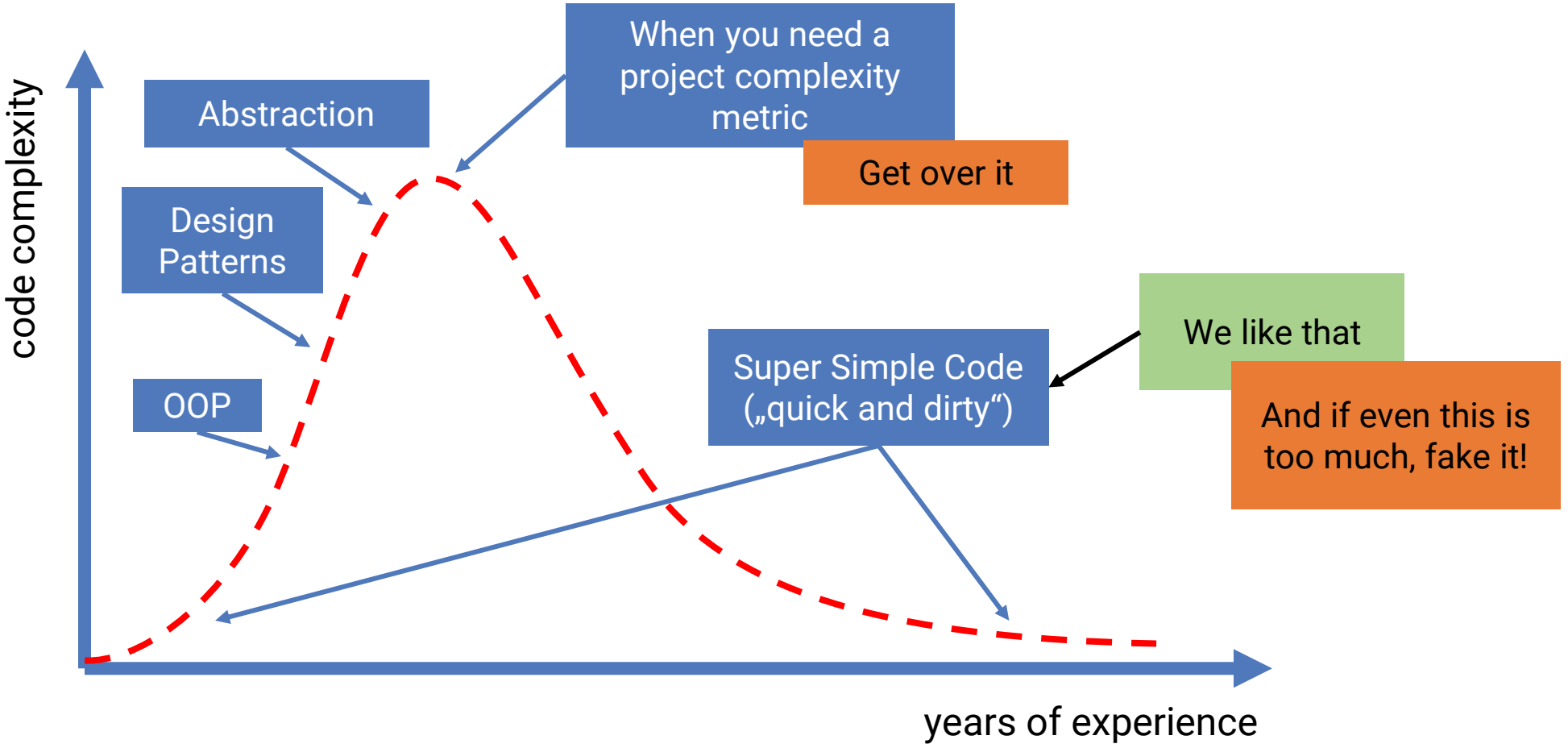
No need to test it, because it's stupid!

Teams

- Allowed group size: **3 persons** (no < 3, no > 3)
- Each group **presents the progress** of their project as a whole
- The group will be **rated as a whole** (default, but you can change that)
- **Group conflicts**
  - First, try to **solve conflicts internally** but…
  - If a conflict persists and you see that at least one person is getting into trouble

  → contact me!

Mountain of Code Complexity



Adapted from https://twitter.com/flaviocopes/status/1580227345612689408

Top 10 of why people fail…

1. You think that this course is super easy → **Nope.** It is very tricky and complex.
2. You think you can start at the end → **Start now.** Never put off your work!
3. You are doing repetitive tasks → **Automate it.** If not, leave it.
4. You don't talk to each other → **Establish social competence**.
5. Your measure wasn't properly recorded → **Test your own prototype before starting**.
6. You're implementing too much → **Focus on your research question**. Drop fancy features.
7. You have no participants → All people in this course must **attend at least three studies**.
8. You don't have the right equipment → **Talk to us. You will get it.**
9. You have more important things to do → **We don't care.**
10. You found original research doing the same → **Adapt your research question**. Talk to us.

In a perfect world your research project…

- **…has a story**: convincing, relevant, structured, focused, a “message”
- **…is novel**: original, creative, strange, interesting
- **…is correct**: scientific, unbiased, objective, replicable, reproduceable
- **…is founded**: correct methodology, brought into context with related work
- **…is structured**: systematic, organized, planned
- **…is understandable**: clear, logical, throrough (claim → reason → evidence)
- **…subtly highlights your skills**: programming, social, management, graphics
- **…properly reports**: clear and concise language, no blah blah (!)
- **…is ready for publishing**: even when you have no findings

General Project Procedure

1. Find a group & choose **a topic** (we set them!)
2. Prepare the topic & screen **important literature**
3. Identify and motivate your **research question**, establish **hypotheses**
4. Implement a **prototype**, **artifact** or **stimuli**
5. Design and conduct a (1) **user study** or (2) **field or online survey**
6. Analyze and **evaluate** your results
7. Present your **findings**
8. Write a **scientific paper** (6 - 10 pages excl. references)
   - Release your data and source code on github (open science)

Your Paper

- **Scientific report of your evaluation** (your project)
  - You will learn and use Latex
    - `\documentclass[manuscript,screen,review]{acmart}`
  - Papers may be submitted in German & English
  - Paper length: 6 pages (excluding references)
  - Template: ACM Single Column Master Template
    https://www.overleaf.com/latex/templates/association-for-computing-machinery-acm-large-1-column-format-template/fsyrjmfzcwyy
- **Additional materials**
  - **Private** GitHub repository with
    - complete project & source code
    - anonymized datasets

The Name of the Title is Hope

111

- Please ensure that you use the right template; a single column format must be used for the reviewing phase. **Use of different templates or formats may result in desk reject.**

Three Types of Evaluations

1. **Summative Evaluations** (e.g., experimental user studies in the lab)
2. **Formative Evaluations** (e.g., qualitative interviews / focus groups)
3. **Literature Reviews** (e.g., a scoping review)

The three evaluation types in HCI are different.
However, they basically require the same amount of time and effort.

- **Most projects have overlaps with the other types** (a summative evaluation can also have formative components, literature reviews can occur in both, etc.)
- Please **decide based on**: **personal interests**, **skills** and **within the team**

Summative Evaluations

- **Quantitatively assess the objective and/or subjective measures**
- **Typically controlled environments or surveys**
- Collection of empirical data that can be **statistically analyzed** to draw conclusions
- This approach is crucial for **validating hypotheses** about how design decisions impact user performance and satisfaction
- Pros: highest impact, highest reputation
- Cons: careful study designs, statistical analysis

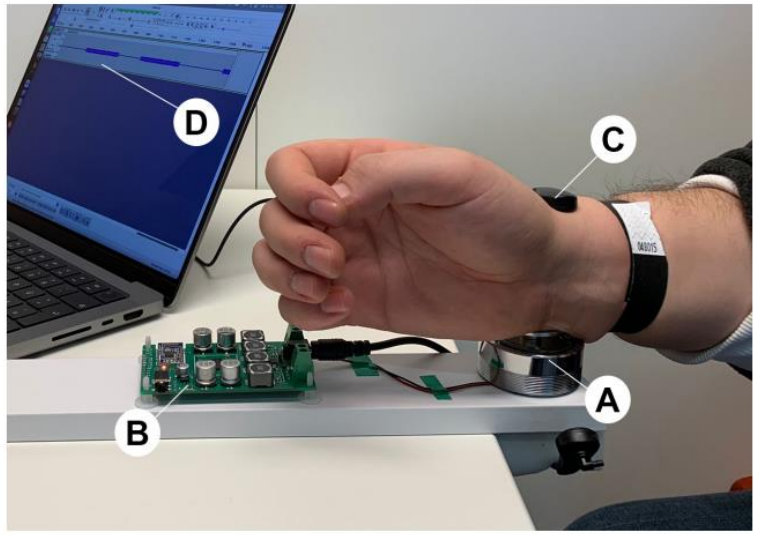
Formative Evaluations

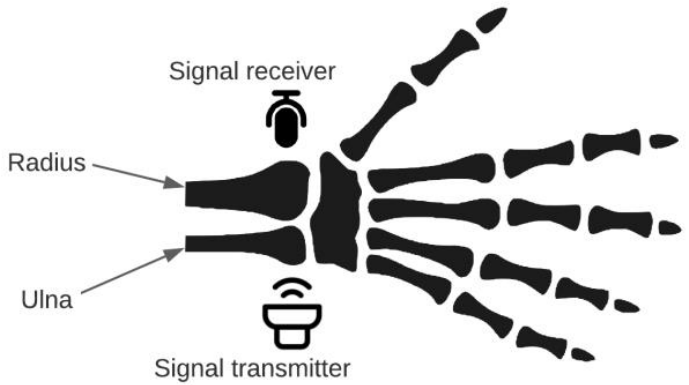
- In **single or group interviews**, researchers can gain deep insights into the personal experiences, preferences, opinions, and challenges faced by users
- **Generate ideas, understand requirements, foster discussions** that can reveal commonalities and differences in user needs and expectations
- Develop and understand the **design of low-level prototypes** and **design spaces**
- Pros: deep insights, flexible study designs
- Cons: interpretation of data, difficult synthesis

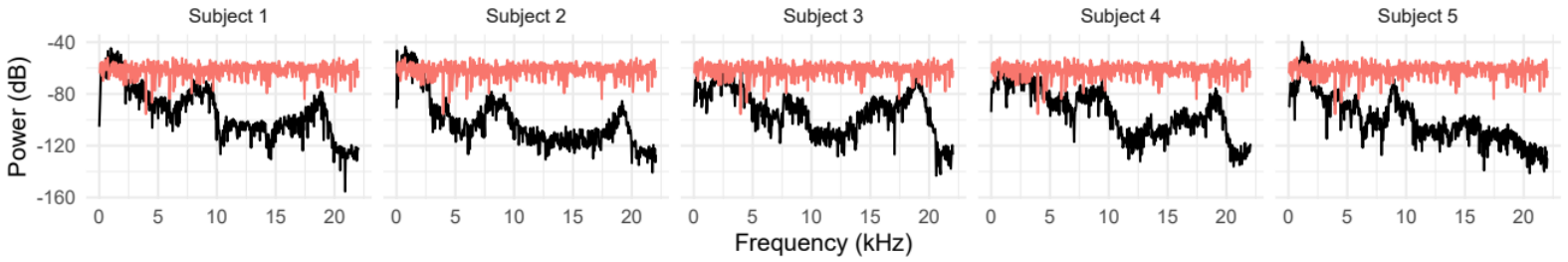
Literature Reviews

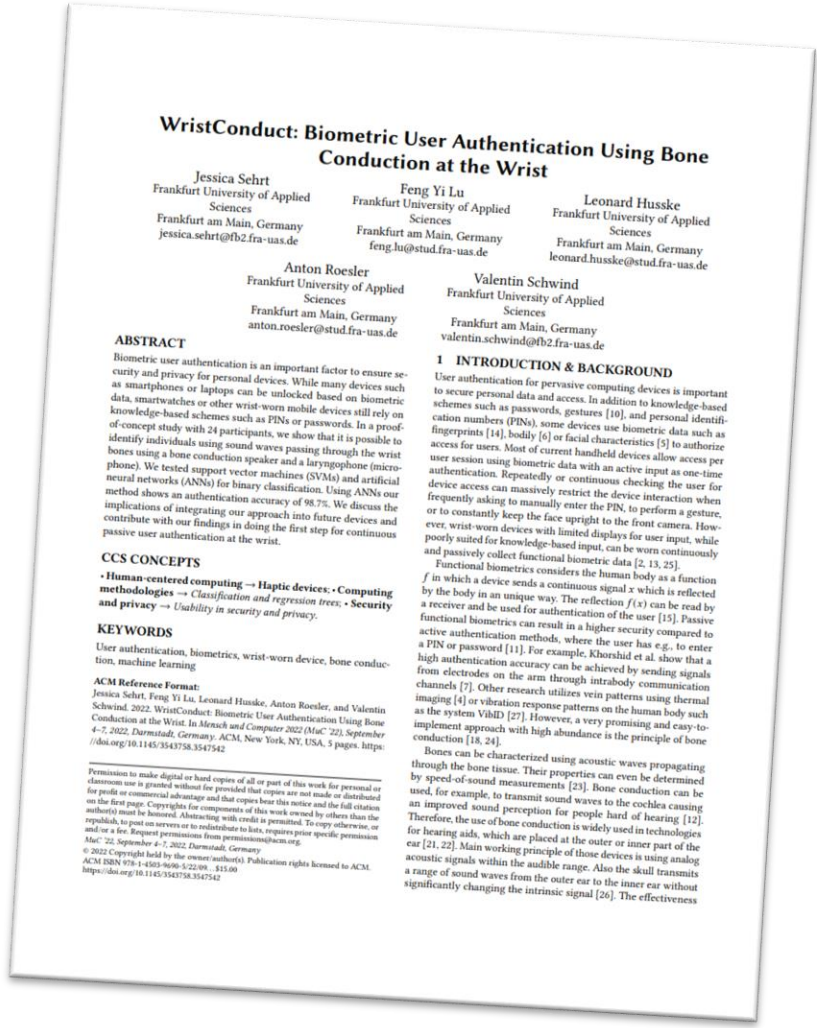
- **Systematic or scoping reviews**, play a foundational role in synthesizing existing research findings and identifying gaps in the literature
- **Understand and overview the current state of knowledge** on a particular topic
- Map the field and identify key concepts, theories, and sources of evidence, which can **inform future research directions and methodologies**.
- Pros: get a broad overview, very resource efficient
- Cons: information overload, difficult synthesis

Example from THIS course: WristConduct









WristConduct: Biometric User Authentication Using Bone Conduction at the Wrist

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Valentin Schwind, Frankfurt University of Applied Sciences, Frankfurt am Main, Germany, valentin.schwind@fb2.fra-uas.de

ABSTRACT

Biometric user authentication is an important factor to ensure security and privacy for personal devices. While many devices such as smartphones or laptops can be unlocked based on biometric data, smartwatches or other wrist-worn mobile devices still rely on knowledge-based schemes such as PINs or passwords. In a proof-of-concept study with 24 participants, we show that it is possible to identify individuals using sound waves passing through the wrist bones using a bone conduction speaker and a laryngophone (microphone). We tested support vector machines (SVMs) and artificial neural networks (ANNs) for binary classification. Using ANNs our method shows an authentication accuracy of 98.7%. We discuss the implications of integrating our approach into future devices and contribute with our findings in doing the first step for continuous passive user authentication at the wrist.

CCS CONCEPTS

• Human-centered computing → Haptic devices; • Computing methodologies → Classification and regression trees; • Security and privacy → Usability in security and privacy.

KEYWORDS

User authentication, biometrics, wrist-worn device, bone conduction, machine learning

ACM Reference Format:

Jessica Sehrt, Feng Yi Lu, Leonard Husske, Anton Roesler, and Valentin Schwind. 2022. WristConduct: Biometric User Authentication Using Bone Conduction at the Wrist. In *Mensch und Computer 2022 (MuC '22), September 4–7, 2022, Darmstadt, Germany.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3543758.3547542

ACM ISBN 978-1-4503-9690-5/22/09…$15.00
https://doi.org/10.1145/3543758.3547542

1 INTRODUCTION & BACKGROUND

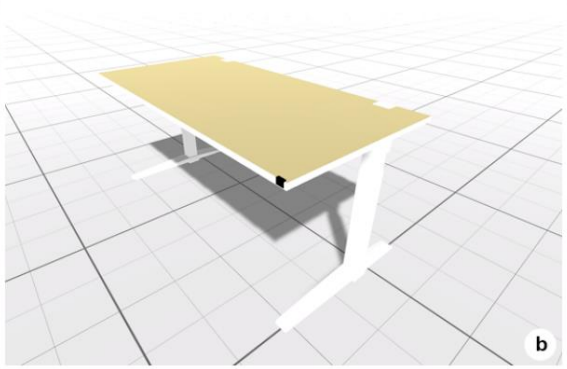
User authentication for pervasive computing devices is important to secure personal data and access. In addition to knowledge-based schemes such as passwords, gestures [10], and personal identification numbers (PINs), some devices use biometric data such as fingerprints [14], bodily [6] or facial characteristics [5] to authorize access for users. Most of current handheld devices allow access per user session using biometric data with an active input as one-time authentication. Repeatedly or continuous checking the user for device access can massively restrict the device interaction when frequently asking to manually enter the PIN, to perform a gesture, or to constantly keep the face upright to the front camera. However, wrist-worn devices with limited displays for user input, while poorly suited for knowledge-based input, can be worn continuously and passively collect functional biometric data [2, 13, 25].

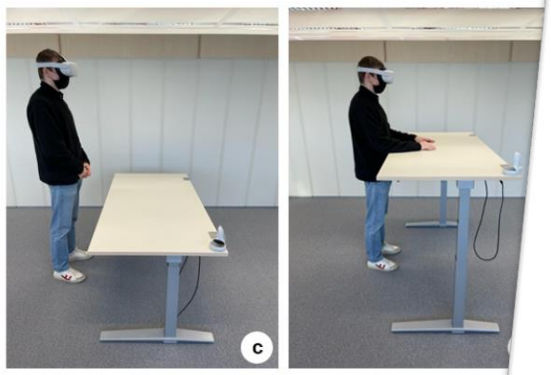
Functional biometrics considers the human body as a function f in which a device sends a continuous signal x which is reflected by the body in an unique way. The reflection $f(x)$ can be read by a receiver and be used for authentication of the user [15]. Passive functional biometrics can result in a higher security compared to active authentication methods, where the user has e.g., to enter a PIN or password [11]. For example, Khorshid et al. show that a high authentication accuracy can be achieved by sending signals from electrodes on the arm through intrabody communication channels [7]. Other research utilizes vein patterns using thermal imaging [4] or vibration response patterns on the human body such as the system VibID [27]. However, a very promising and easy-to-implement approach with high abundance is the principle of bone conduction [18, 24].

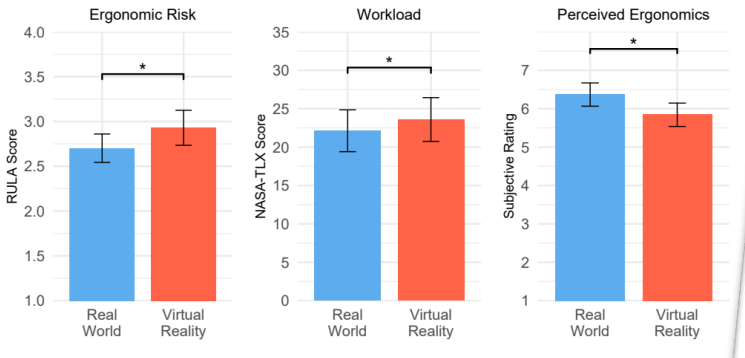
Bones can be characterized using acoustic waves propagating through the bone tissue. Their properties can even be determined by speed-of-sound measurements [23]. Bone conduction can be used, for example, to transmit sound waves to the cochlea causing an improved sound perception for people hard of hearing [12]. Therefore, the use of bone conduction is widely used in technologies for hearing aids, which are placed at the outer or inner part of the ear [21, 22]. Main working principle of those devices is using analog acoustic signals within the audible range. Also the skull transmits a range of sound waves from the outer ear to the inner ear without significantly changing the intrinsic signal [26]. The effectiveness

WristConduct: Biometric User Authentication Using Bone Conduction at the Wrist. Jessica Sehrt, Feng Yi Lu, Leonard Husske, Anton Roesler, and Valentin Schwind. In Mensch und Computer 2022 (MuC '22), September 4-7, 2022, Darmstadt, Germany, New York, NY, USA, 2022. ACM. ISBN 978-1-4503-9690-5/22/09. https://doi.org/10.1145/3543758.3547542

Example from THIS course: Ergonomics at Virtual Desks







The Negative Effect on Postural Ergonomics of Non-Sedentary Workplace Desks in Virtual Reality

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ABSTRACT

Virtual reality (VR) is gaining increasing importance in an increasing number of places in daily life, particularly when gaming or working. Moreover, immersive activities are often performed while standing at physical desks and current devices can even register the physical properties of a virtual workplace to match the virtual content with haptics in the real world in front of the user. However, little is known about the effects of VR on how users perceive and ergonomically adapt to workplace desks when wearing a head-mounted display (HMD). In this user study, we conducted an experiment with 19 participants to investigate the effects of non-sedentary VR on the postural risk level, workload, and preferred desk height. The results indicate that being in VR negatively influences objective and subjective measures of ergonomics and increases postural risk while the preferred desk height remained unaffected. We found evidence that wearing the HMD negatively affects the neck posture at non-sedentary workplace desks. We contribute with our findings and highlight the need for improving the field-of-view and weight of HMDs for lower postural risk levels at workplace desks in non-seated VR.

CCS CONCEPTS

• Human-centered computing → Virtual reality; Haptic devices; Empirical studies in HCI.

KEYWORDS

Ergonomics, height adjustable desk, virtual workplace, virtual reality, head-mounted displays

ACM Reference Format:
Jessica Sehrt, Henrico Putra Neumann, Julian Niclas Wenzel, Luca Kindermann, Valentin Schwind. 2022. The Negative Effect on Postural Ergonomics of Non-Sedentary Workplace Desks in Virtual Reality. In Mensch und Computer 2022 (MuC '22), September 4–7, 2022, Darmstadt, Germany. ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3543758.3547541

1 INTRODUCTION AND BACKGROUND

Standing is a body posture often taken by workers or gamers when the surrounding area must to be comfortably reached with the arms or when the legs cannot comfortably be placed [7, 31]. While standing at workstations can have a small but statistically significant positive effect in terms of fasting blood glucose levels and the body mass index (BMI) [29], it also reduces the risk for real postural injuries such as tendinosis, tension neck syndrome, and back pain [14, 24, 33]. In addition to the health-related issues, personal preferences in workplace comfort likely led to an increasing spread of height-adjustable desks that also so allow standing in front of the workstation [10, 28].

Height-adjustable desks are not only used for ergonomic reasons, but also for various applications that need to alternate between standing and sitting. Particularly in virtual reality (VR), there is also an increasing number of applications that can only be used effectively while standing, especially when interaction require a larger space for tracking and to avoid collisions with the physical environment [3]. Thus, for spatial and embodied interaction as well as for consistent (full body) tracking in VR with head-mounted displays (HMDs) the ability to stand and adjust the table height can be crucial not only for improved ergonomics of workplaces, but also for the optimal usage of such systems.

Since using VR applications and tracking that often requires interaction that cannot be performed while seated, ergonomics of height-adjustable desks are particularly important for users who want to use such desks in VR. However, little is known about the ergonomics of VR combined with work desks while standing. Particularly, while considering the phenomenon of distance underestimation in VR with HMDs [2, 13, 21], it is also important to understand if there are differences in the preferred table height adjustments. As more and more users are likely to spend more and more time with immersive technologies, health issues as a result of bad ergonomics

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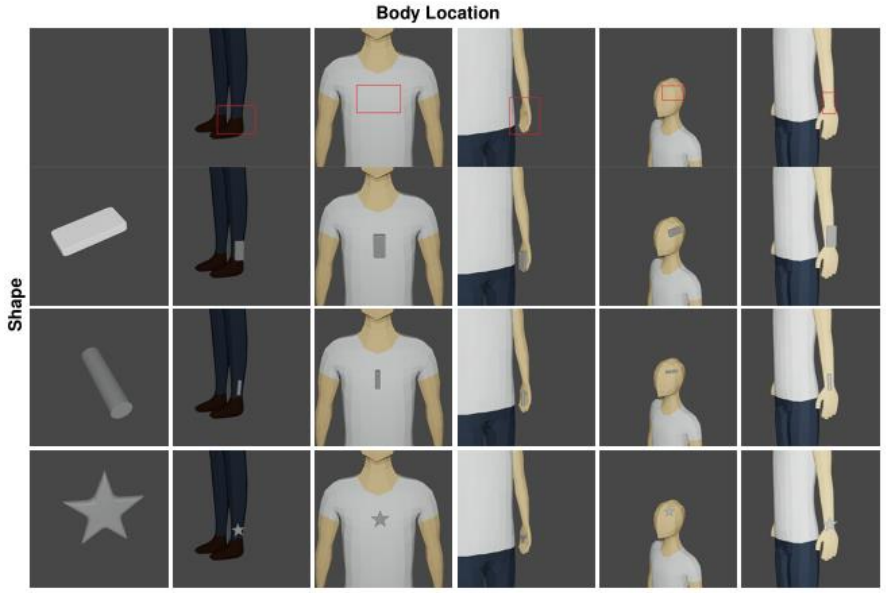
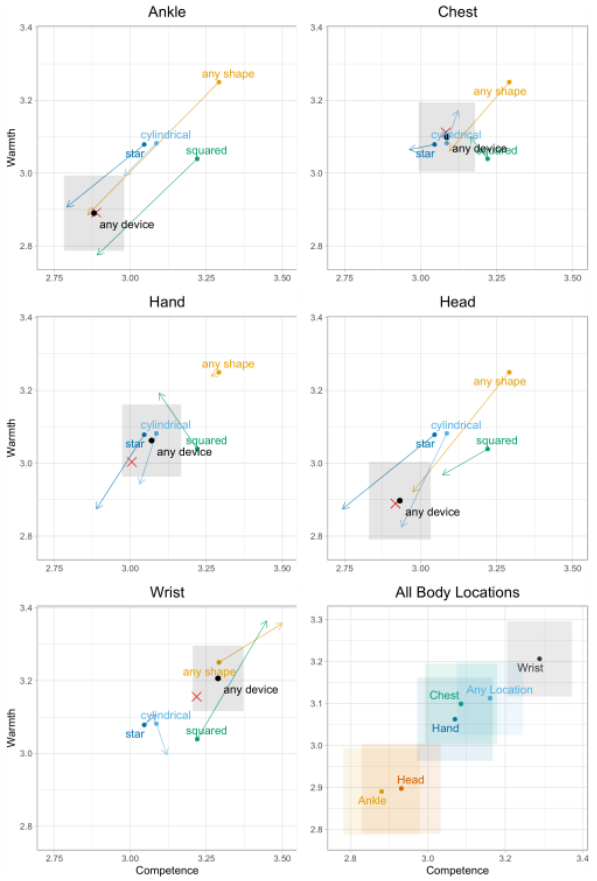
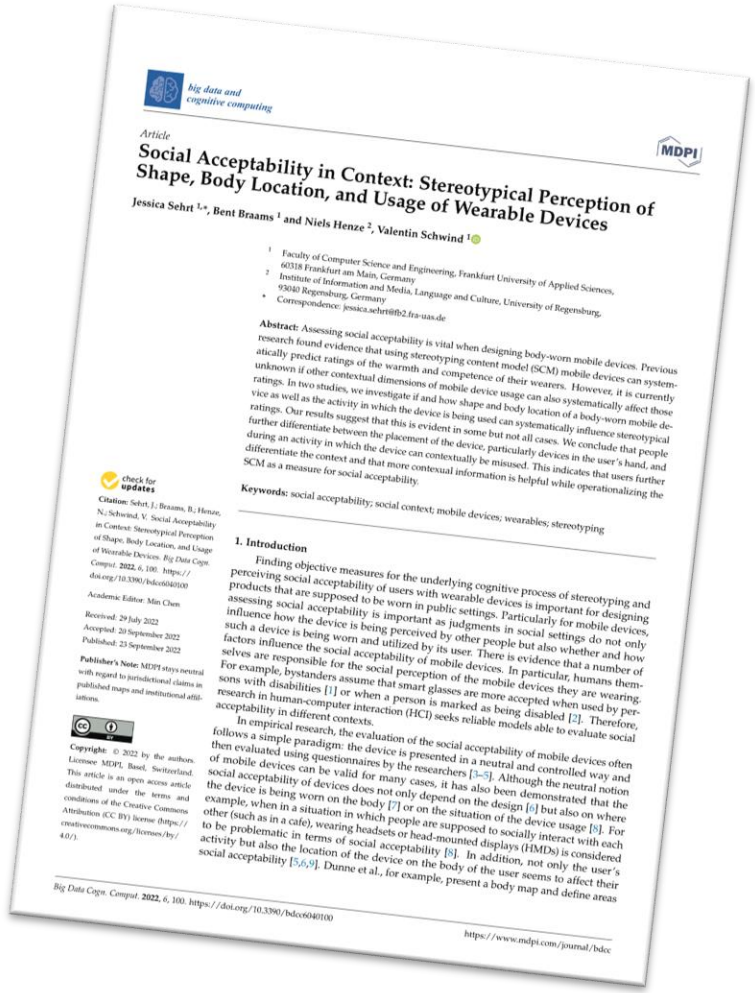
The Negative Effect on Postural Ergonomics of Non-Sedentary Workplace Desks in Virtual Reality. Jessica Sehrt, Henrico Putra Neumann, Julian Niclas Wenzel, Luca Kindermann, and Valentin Schwind. In Mensch und Computer 2022 (MuC '22), New York, NY, USA, 2022. ACM. ISBN 978-1-4503-9690-5/22/09. https://doi.org/10.1145/3543758.3547541

Example from THIS course: Social Acceptability of Body Locations







big data and cognitive computing

Article

MDPI

Social Acceptability in Context: Stereotypical Perception of Shape, Body Location, and Usage of Wearable Devices

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Abstract: Assessing social acceptability is vital when designing body-worn mobile devices. Previous research found evidence that using stereotyping content model (SCM) mobile devices can systematically predict ratings of the warmth and competence of their wearers. However, it is currently unknown if other contextual dimensions of mobile device usage can also systematically affect those ratings. In two studies, we investigate if and how shape and body location of a body-worn mobile device as well as the activity in which the device is being used can systematically influence stereotypical ratings. Our results suggest that this is evident in some but not all cases. We conclude that people further differentiate between the placement of the device, particularly devices in the user's hand, and during an activity in which the device can contextually be misused. This indicates that users further differentiate the context and that more contexual information is helpful while operationalizing the SCM as a measure for social acceptability.

Keywords: social acceptability; social context; mobile devices; wearables; stereotyping

check for updates

Citation: Sehrt, J.; Braams, B.; Henze, N.; Schwind, V. Social Acceptability in Context: Stereotypical Perception of Shape, Body Location, and Usage of Wearable Devices. *Big Data Cogn. Comput.* **2022**, *6*, 100. https://doi.org/10.3390/bdcc6040100

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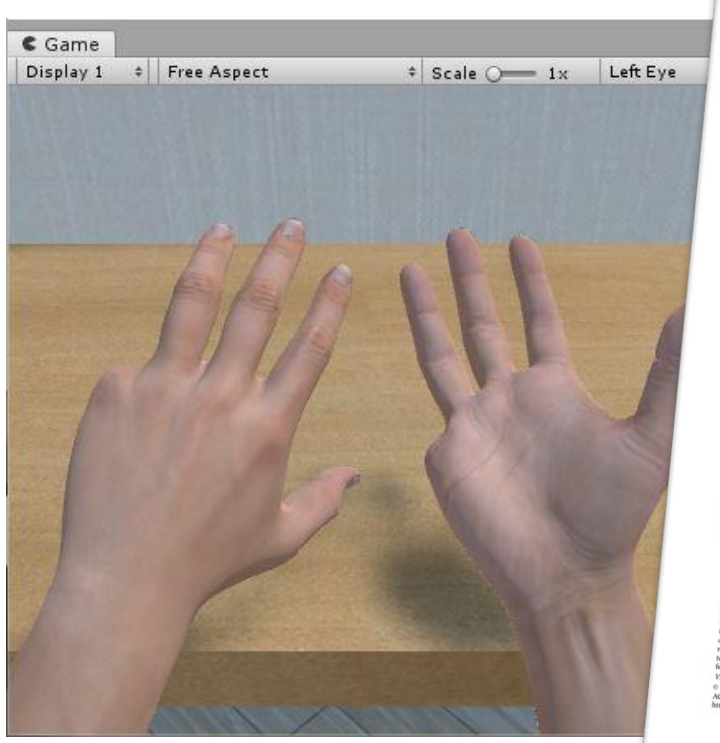
1. Introduction

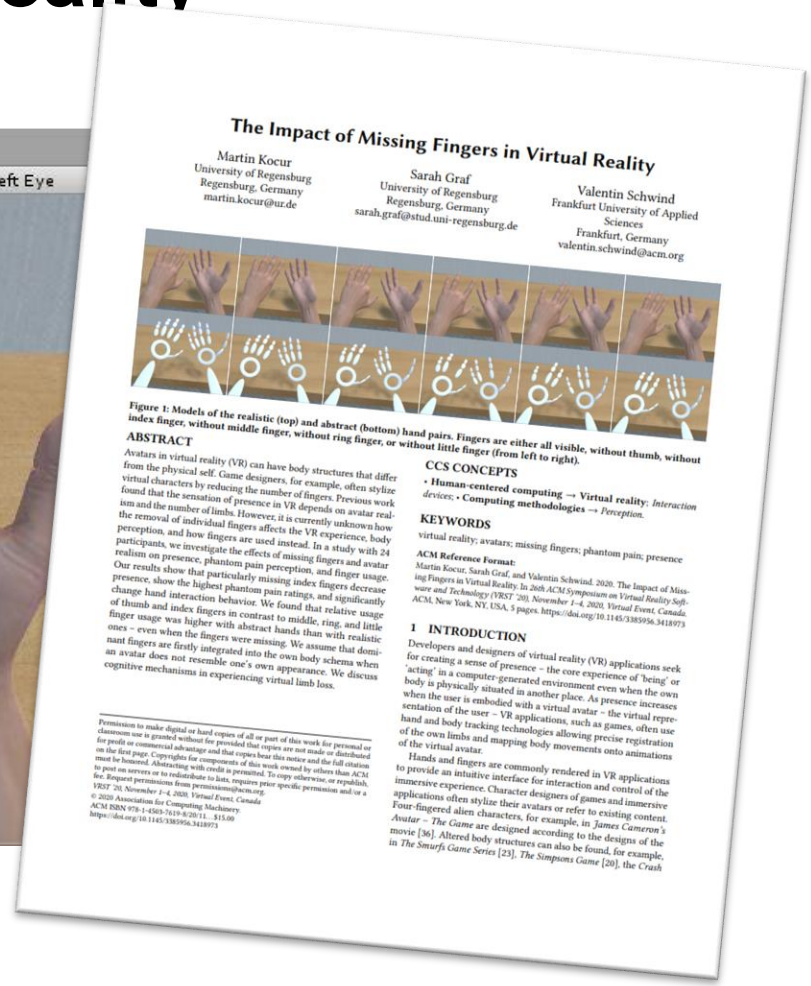
Finding objective measures for the underlying cognitive process of stereotyping and perceiving social acceptability of users with wearable devices is important for designing products that are supposed to be worn in public settings. Particularly for mobile devices, assessing social acceptability is important as judgments in social settings do not only influence how the device is being perceived by other people but also whether and how such a device is being worn and utilized by its user. There is evidence that a number of factors influence the social acceptability of mobile devices. In particular, humans themselves are responsible for the social perception of the mobile devices they are wearing. For example, bystanders assume that smart glasses are more accepted when used by persons with disabilities [1] or when a person is marked as being disabled [2]. Therefore, research in human-computer interaction (HCI) seeks reliable models able to evaluate social acceptability in different contexts.

In empirical research, the evaluation of the social acceptability of mobile devices often follows a simple paradigm: the device is presented in a neutral and controlled way and then evaluated using questionnaires by the researchers [3–5]. Although the neutral notion of mobile devices can be valid for many cases, it has also been demonstrated that the social acceptability of devices does not only depend on the design [6] but also on where the device is being worn on the body [7] or on the situation of the device usage [8]. For example, when in a situation in which people are supposed to socially interact with each other (such as in a cafe), wearing headsets or head-mounted displays (HMDs) is considered to be problematic in terms of social acceptability [8]. In addition, not only the user's activity but also the location of the device on the body of the user seems to affect their social acceptability [5,6,9]. Dunne et al., for example, present a body map and define areas

Sehrt, Jessica, Bent Braams, Niels Henze, and Valentin Schwind. 2022. "Social Acceptability in Context: Stereotypical Perception of Shape, Body Location, and Usage of Wearable Devices" Big Data and Cognitive Computing 6, no. 4: 100. https://doi.org/10.3390/bdcc6040100

Another example: Few Fingers in Virtual Reality





The Impact of Missing Fingers in Virtual Reality

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Figure 1: Models of the realistic (top) and abstract (bottom) hand pairs. Fingers are either all visible, without thumb, without index finger, without middle finger, without ring finger, or without little finger (from left to right).

ABSTRACT

Avatars in virtual reality (VR) can have body structures that differ from the physical self. Game designers, for example, often stylize virtual characters by reducing the number of fingers. Previous work found that the sensation of presence in VR depends on avatar realism and the number of limbs. However, it is currently unknown how the removal of individual fingers affects the VR experience, body perception, and how fingers are used instead. In a study with 24 participants, we investigate the effects of missing fingers and avatar realism on presence, phantom pain perception, and finger usage. Our results show that particularly missing index fingers decrease presence, show the highest phantom pain ratings, and significantly change hand interaction behavior. We found that relative usage of thumb and index fingers in contrast to middle, ring, and little finger usage was higher with abstract hands than with realistic ones – even when the fingers were missing. We assume that dominant fingers are firstly integrated into the own body schema when an avatar does not resemble one's own appearance. We discuss cognitive mechanisms in experiencing virtual limb loss.

CCS CONCEPTS

• Human-centered computing → Virtual reality; Interaction devices; • Computing methodologies → Perception.

KEYWORDS

virtual reality; avatars; missing fingers; phantom pain; presence

ACM Reference Format:

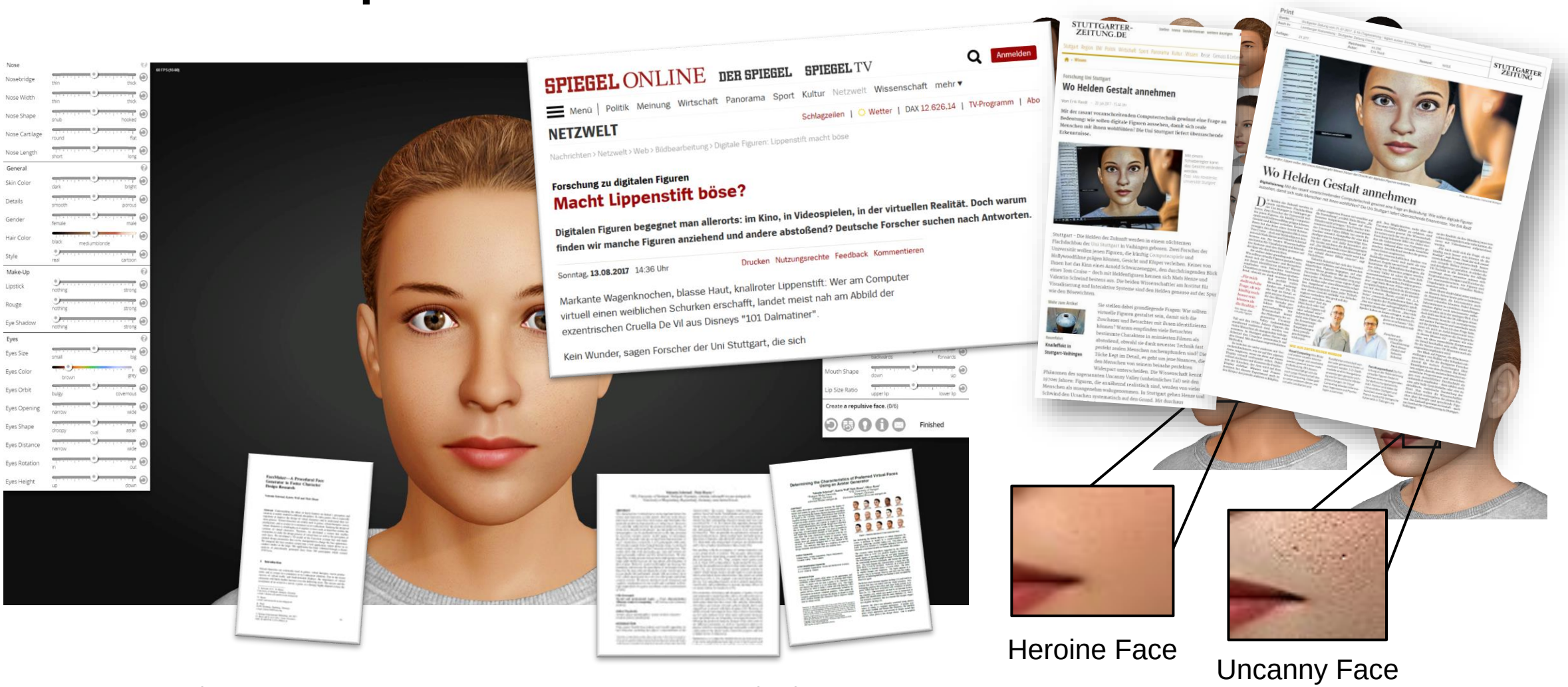
1 INTRODUCTION

Developers and designers of virtual reality (VR) applications seek for creating a sense of presence – the core experience of 'being' or 'acting' in a computer-generated environment even when the own body is physically situated in another place. As presence increases when the user is embodied with a virtual avatar – the virtual representation of the user – VR applications, such as games, often use hand and body tracking technologies allowing precise registration of the own limbs and mapping body movements onto animations of the virtual avatar.

Hands and fingers are commonly rendered in VR applications to provide an intuitive interface for interaction and control of the immersive experience. Character designers of games and immersive applications often stylize their avatars or refer to existing content. Four-fingered alien characters, for example, in *James Cameron's Avatar – The Game* are designed according to the designs of the movie [36]. Altered body structures can also be found, for example, in *The Smurfs Game Series* [23], *The Simpsons Game* [20], the *Crash*

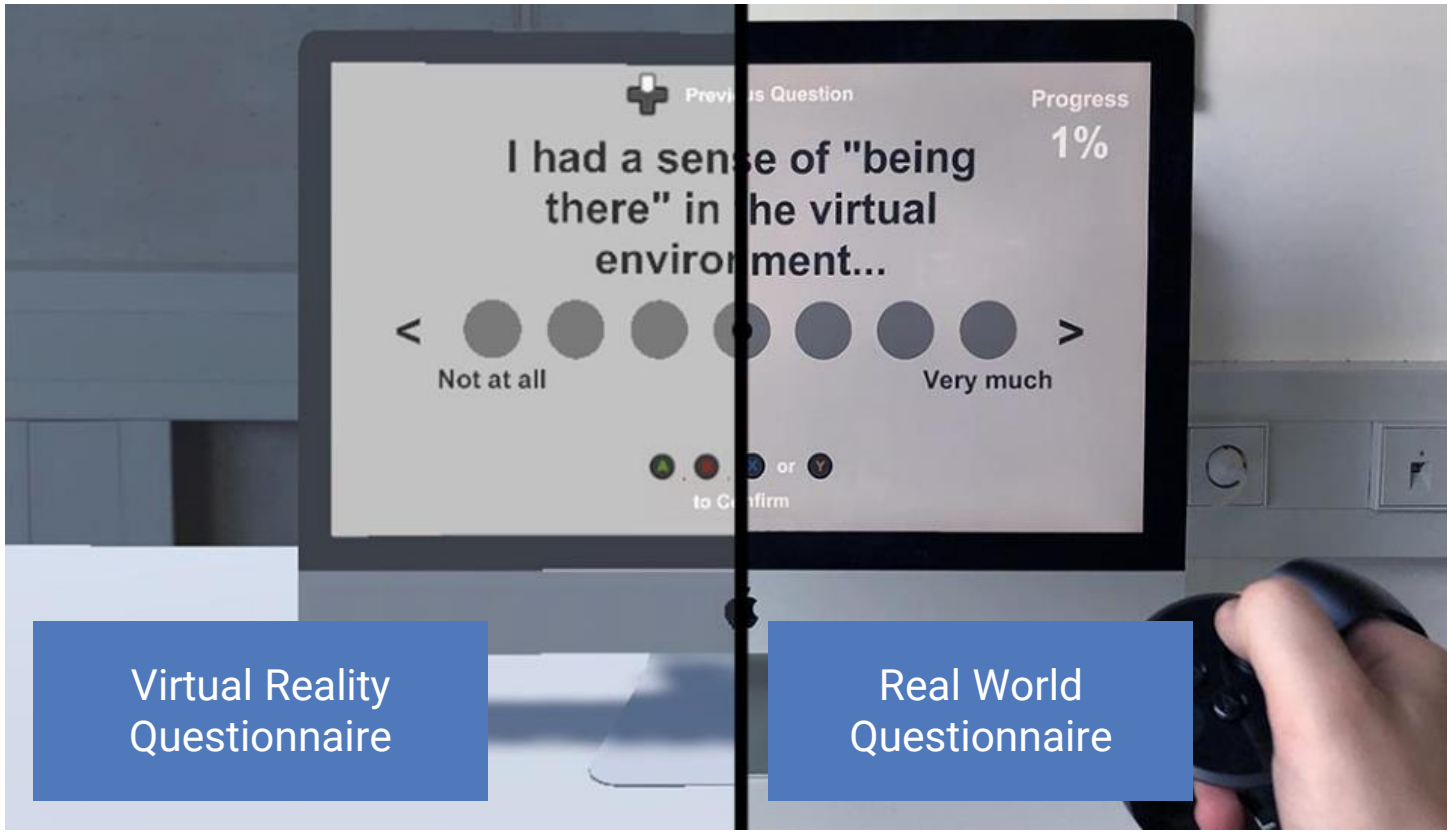
Martin Kocur, Sarah Graf, and Valentin Schwind. 2020. The Impact of Missing Fingers in Virtual Reality. In 26th ACM Symposium on Virtual Reality Software and Technology (VRST '20). Association for Computing Machinery, New York, NY, USA, Article 4, 1–5. DOI:https://doi.org/10.1145/3385956.3418973

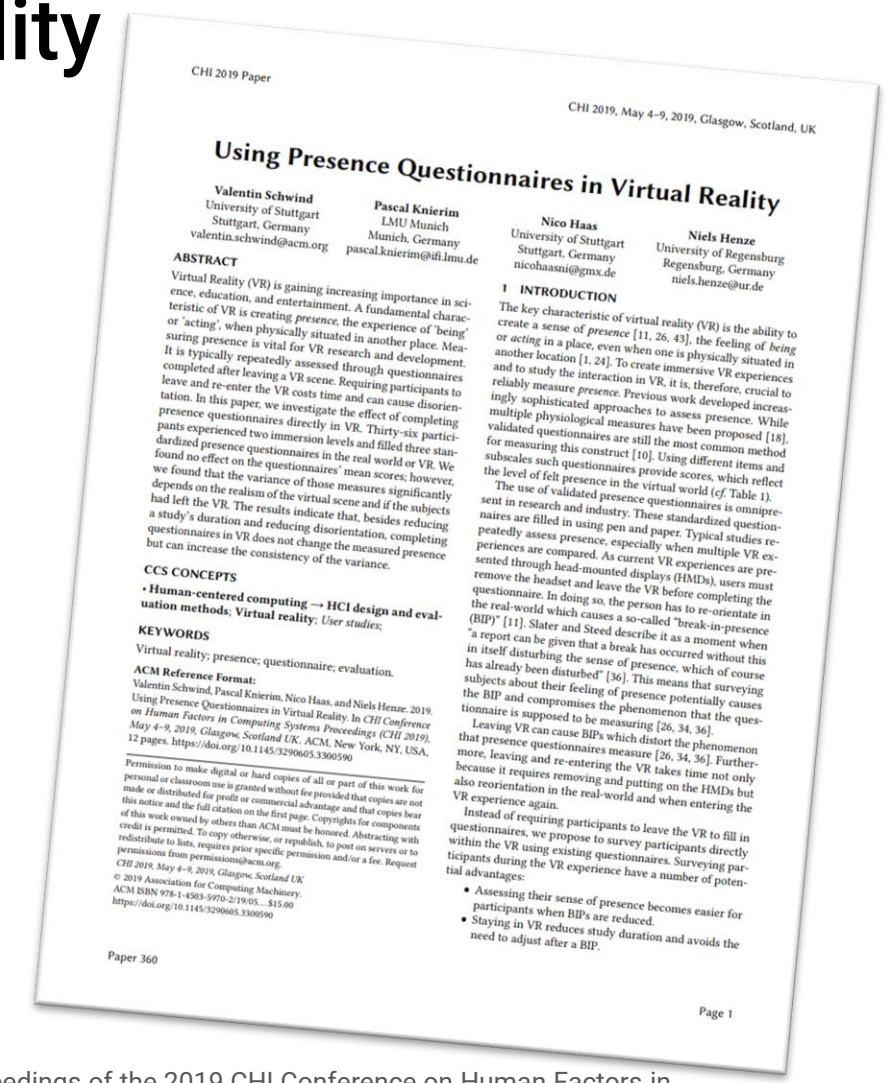
Another example: FaceMaker an Online Avatar Generator



V. Schwind, Katrin Wolf, Niels Henze, and Oliver Korn. 2015. Determining the Characteristics of Preferred Virtual Faces Using an Avatar Generator. In Proc. CHI PLAY '15

Example: Questionnaires in Virtual Reality





CHI 2019 Paper

CHI 2019, May 4–9, 2019, Glasgow, Scotland, UK

Using Presence Questionnaires in Virtual Reality

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ABSTRACT

Virtual Reality (VR) is gaining increasing importance in science, education, and entertainment. A fundamental characteristic of VR is creating *presence*, the experience of 'being' or 'acting', when physically situated in another place. Measuring presence is vital for VR research and development. It is typically repeatedly assessed through questionnaires completed after leaving a VR scene. Requiring participants to leave and re-enter the VR costs time and can cause disorientation. In this paper, we investigate the effect of completing presence questionnaires directly in VR. Thirty-six participants experienced two immersion levels and filled three standardized presence questionnaires in the real world or VR. We found no effect on the questionnaires' mean scores; however, we found that the variance of those measures significantly depends on the realism of the virtual scene and if the subjects had left the VR. The results indicate that, besides reducing a study's duration and reducing disorientation, completing questionnaires in VR does not change the measured presence but can increase the consistency of the variance.

CCS CONCEPTS

• **Human-centered computing** → **HCI design and evaluation methods**; **Virtual reality**; *User studies*;

KEYWORDS

Virtual reality; presence; questionnaire; evaluation.

ACM Reference Format:
Valentin Schwind, Pascal Knierim, Nico Haas, and Niels Henze. 2019. Using Presence Questionnaires in Virtual Reality. In *CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4–9, 2019, Glasgow, Scotland UK.* ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3290605.3300590

CHI 2019, May 4–9, 2019, Glasgow, Scotland UK

ACM ISBN 978-1-4503-5970-2/19/05…$15.00
https://doi.org/10.1145/3290605.3300590

1 INTRODUCTION

The key characteristic of virtual reality (VR) is the ability to create a sense of *presence* [11, 26, 43], the feeling of *being* or *acting* in a place, even when one is physically situated in another location [1, 24]. To create immersive VR experiences and to study the interaction in VR, it is, therefore, crucial to reliably measure *presence*. Previous work developed increasingly sophisticated approaches to assess presence. While multiple physiological measures have been proposed [18], validated questionnaires are still the most common method for measuring this construct [10]. Using different items and subscales such questionnaires provide scores, which reflect the level of felt presence in the virtual world (*cf.* Table 1).

The use of validated presence questionnaires is omnipresent in research and industry. These standardized questionnaires are filled in using pen and paper. Typical studies repeatedly assess presence, especially when multiple VR experiences are compared. As current VR experiences are presented through head-mounted displays (HMDs), users must remove the headset and leave the VR before completing the questionnaire. In doing so, the person has to re-orientate in the real-world which causes a so-called "break-in-presence (BIP)" [11]. Slater and Steed describe it as a moment when "a report can be given that a break has occurred without this in itself disturbing the sense of presence, which of course has already been disturbed" [36]. This means that surveying subjects about their feeling of presence potentially causes the BIP and compromises the phenomenon that the questionnaire is supposed to be measuring [26, 34, 36].

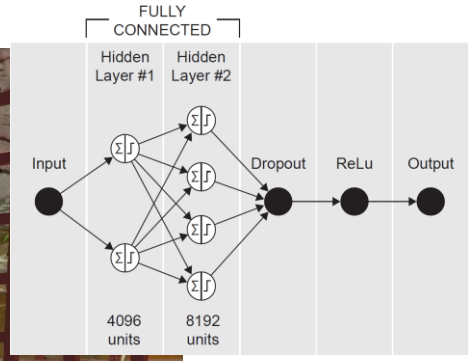
Leaving VR can cause BIPs which distort the phenomenon that presence questionnaires measure [26, 34, 36]. Furthermore, leaving and re-entering the VR takes time not only because it requires removing and putting on the HMDs but also reorientation in the real-world and when entering the VR experience again.

Instead of requiring participants to leave the VR to fill in questionnaires, we propose to survey participants directly within the VR using existing questionnaires. Surveying participants during the VR experience have a number of potential advantages:

- Assessing their sense of presence becomes easier for participants when BIPs are reduced.
- Staying in VR reduces study duration and avoids the need to adjust after a BIP.

Valentin Schwind, Pascal Knierim, Nico Haas, and Niels Henze. 2019. Using Presence Questionnaires in Virtual Reality. Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems. Association for Computing Machinery, New York, NY, USA, Paper 360, 1–12. DOI:https://doi.org/10.1145/3290605.3300590

Another example: Full Body Motion Prediction in VR



The Effects of Full-Body Avatar Movement Predictions in Virtual Reality using Neural Networks

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ABSTRACT

Motion tracking technologies and avatars in virtual reality (VR) showing the movements of the own body enable high levels of presence and a strong illusion of body ownership (IBO) – key features of immersive systems and gaming experiences in virtual environments. Previous work suggests using software-based algorithms that can not only compensate system latency but also predict future movements of the user to increase input performance. However, the effects of movement prediction in VR on input performance are largely unknown. In this paper, we investigate neural network-based predictions of full-body avatar movements in two scenarios: In the first study, we used a standardized 2D Fitts' Law task to examine the information throughput in VR. In the second study, we utilized a full-body VR game to determine the users' performance. We found that both performance and subjective measures in a standardized 2D Fitts' law task could not benefit from the predicted avatar movements. In an immersive gaming scenario, however, the perceived accuracy of the own body location improved. Presence and body assessments remained more stable and were higher than during the Fitts' task. We conclude that machine-learning-based predictions could be used to compensate system-related latency but participants only subjectively benefit under certain conditions.

CCS CONCEPTS

• **Human-centered computing** → **HCI design and evaluation methods**; **Virtual reality**; *User studies.*

KEYWORDS

Virtual reality; presence; questionnaire; break in presence.

ACM Reference Format:
Valentin Schwind, David Halbhuber, Jakob Fehle, Jonathan Sasse, Andreas Pfaffelhuber, Christoph Tögel, Julian Dietz, and Niels Henze. 2020. The Effects of Full-Body Avatar Movement Predictions in Virtual Reality using Neural Networks. In *26th ACM Symposium on Virtual Reality Software and Technology (VRST '20), November 1–4, 2020, Virtual Event, Canada.* ACM, New York, NY, USA, 11 pages. https://doi.org/10.1145/3385956.3418941

1 INTRODUCTION

Motion tracking technologies and avatars in virtual reality (VR) that show the movements of the own body enable high levels of presence and the illusion of body ownership (IBO) – key features of immersive systems and gaming experiences in virtual environments. Strong presence and the IBO is perceived when a sense of full-body ownership [14, 43, 45] and agency [23, 35, 48] allow users to correctly locate their body pose within the virtual environment. When users move their own limbs through active motor control, the brain's expected positions must match the perceived sensory afferent modalities such as gaze, haptics, or body proprioception [7, 14, 41, 51]. Consequently, lacking temporal synchronicity [44] or spatial congruence [8] between the real and the virtual movements can cause conflicting cues from the visual and vestibular afferent and, thus, VR motion sickness or postural instability [1].

To prevent delays between the real and virtual body movements sophisticated tracking systems seek for low to zero latencies. Despite technological advances in hardware that detects movements precisely and quickly, a residual latency remains that can only be compensated by software to provide real-time tracking. However, software-based prediction algorithms are not only capable of estimating a user's recent pose [30] and to remove delays caused by the system [39] but also to go beyond the latency of the hardware and to predict where one's own body will be in an upcoming time step beyond the recent position [15, 27]. However, the effects of machine learning (ML)-based algorithms predicting real-time or future movements of the own body particularly in the context of time critical input performance or immersive experiences are currently unknown. Previous research of linearly extrapolated movements indicates that induced a "lighter weight" sensation [22], however, objective findings about using neural networks able to predict the

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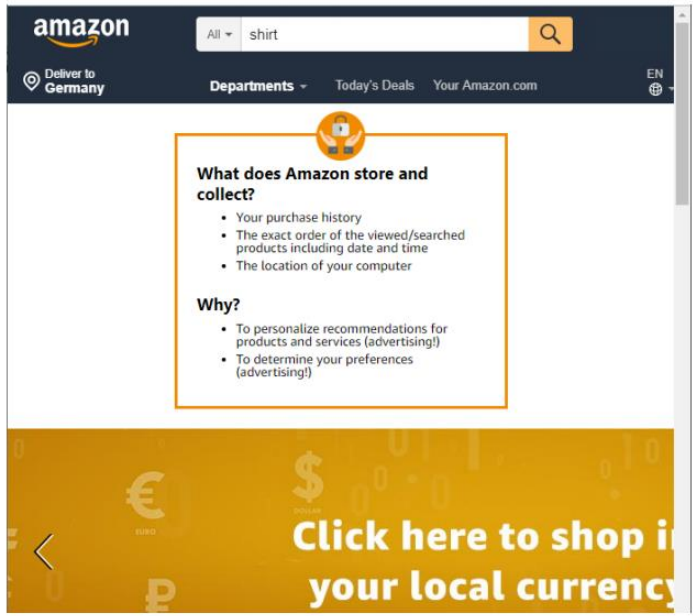
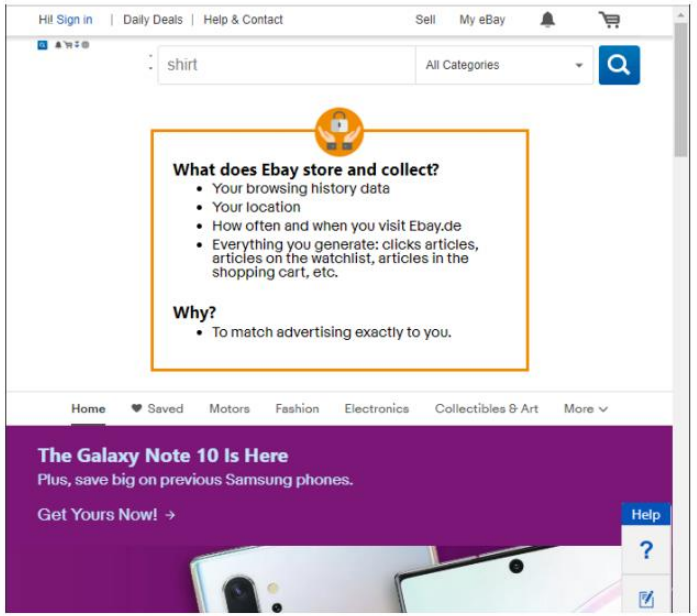
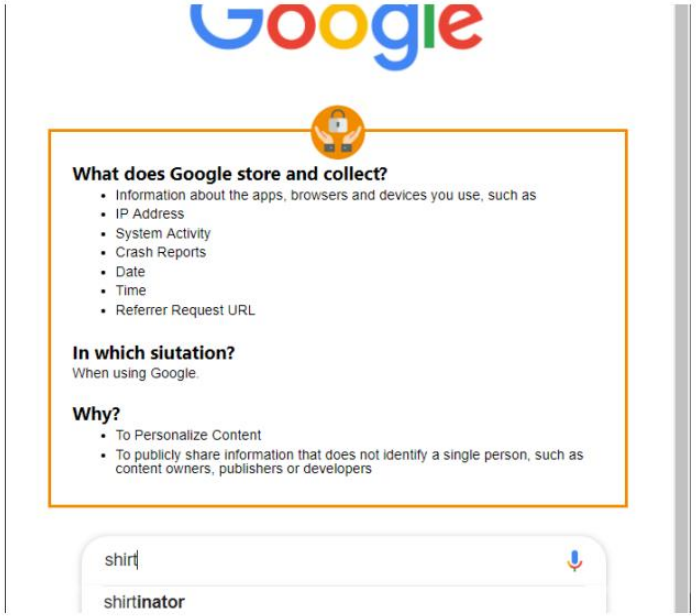
https://doi.org/10.1145/3385956.3418941

Valentin Schwind, David Halbhuber, Jakob Fehle, Jonathan Sasse, Andreas Pfaffelhuber, Christoph Tögel, Julian Dietz, and Niels Henze. 2020. The Effects of Full-Body Avatar Movement Predictions in Virtual Reality using Neural Networks. In 26th ACM Symposium on Virtual Reality Software and Technology (VRST '20). Association for Computing Machinery, New York, NY, USA, Article 28, 1–11. DOI:https://doi.org/10.1145/3385956.3418941

Another example: Contextual Privacy Policies



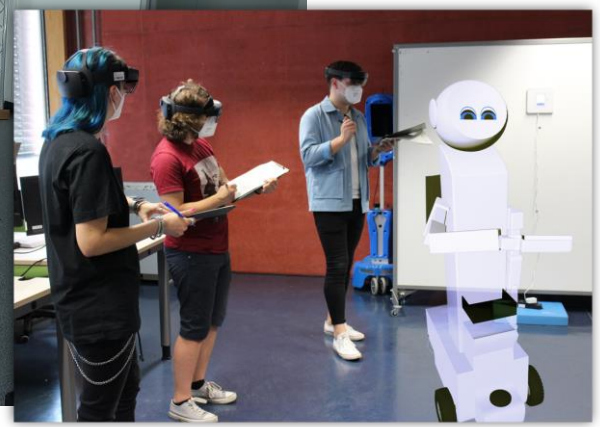




Anna-Marie Ortloff, Maximiliane Windl, Valentin Schwind, and Niels Henze. 2020. Implementation and In Situ Assessment of Contextual Privacy Policies. In Proceedings of the 2020 ACM Designing Interactive Systems Conference (DIS '20). Association for Computing Machinery, New York, NY, USA, 1765–1778. DOI:https://doi.org/10.1145/3357236.3395549

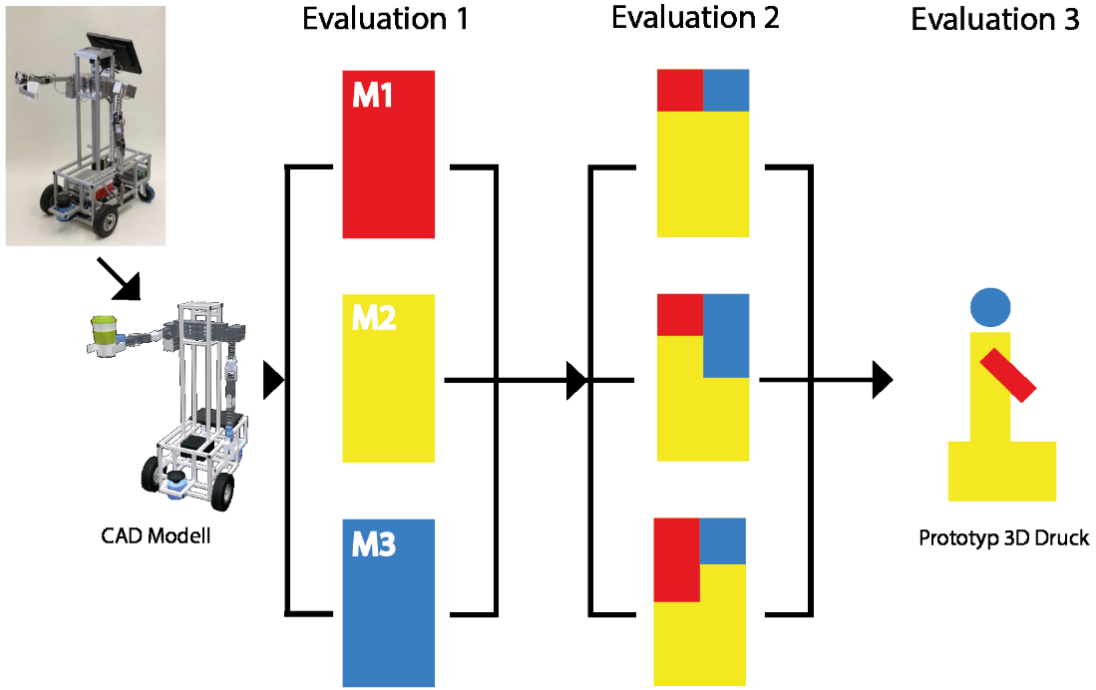
Examples from FUTURE AGING: ROSWITHA

- Research Project links Faculty 2 and Faculty 4 of Frankfurt UAS within the Research Centre FUTURE AGING
- Development of an external appearance (embodiment)



Examples from FUTURE AGING: ROSWITHA

- Evaluation phase 1 and 2: Virtual prototypes in Augmented Reality (AR)
- Evaluation Phase 3: Physical prototype, printed with 3D printer



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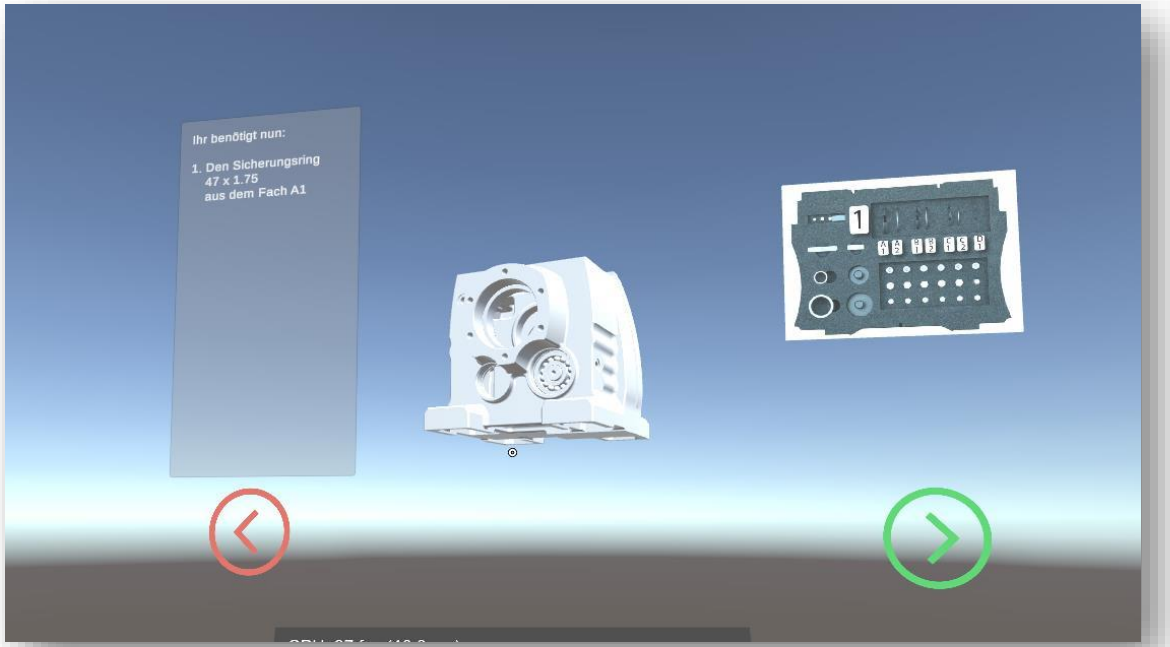
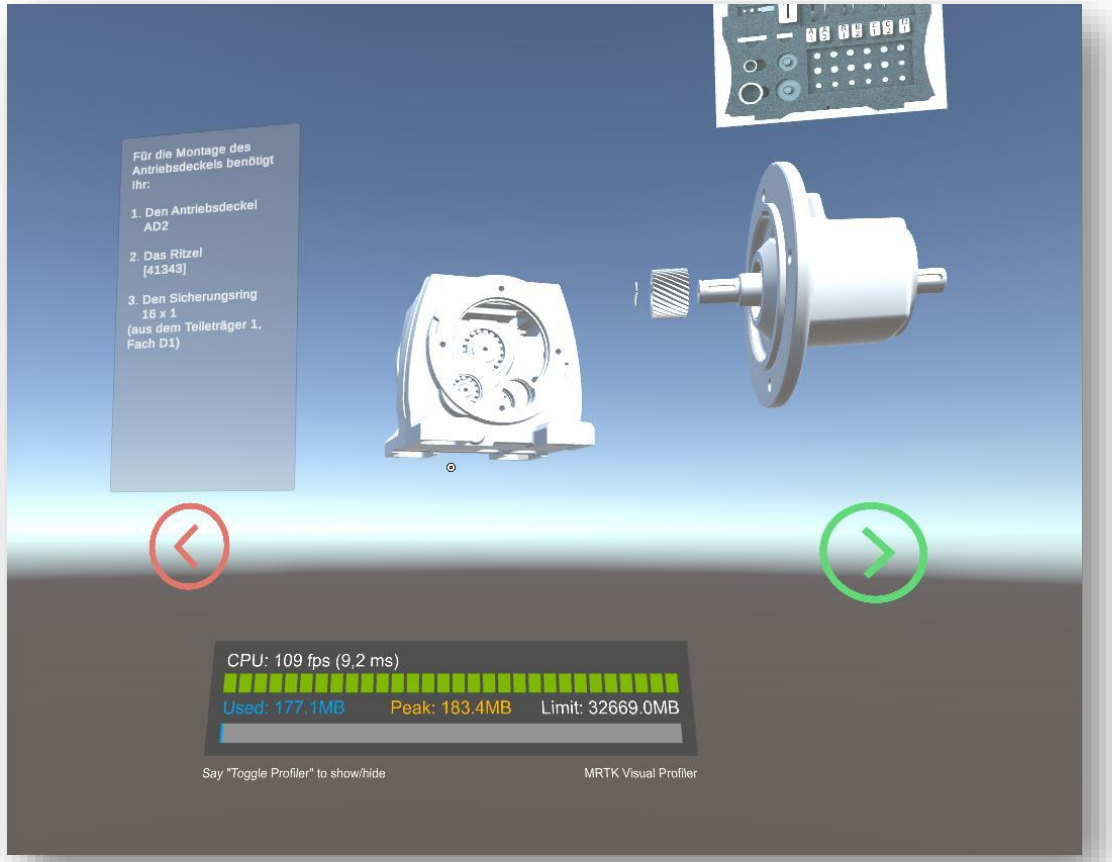
Examples from Industry

- With Microsoft Hololens 2
- For use in machine construction industry

Examples from Industry

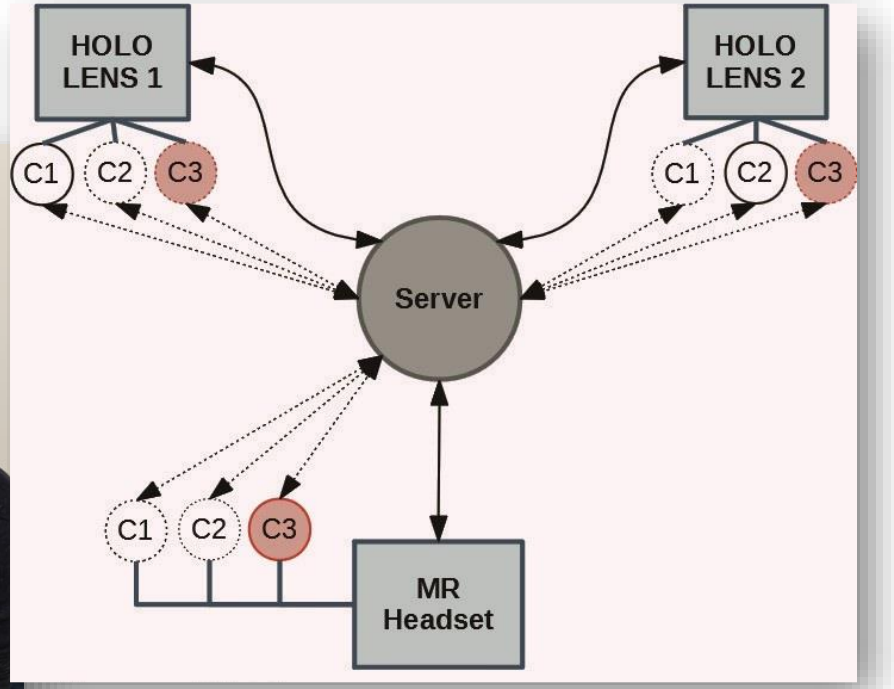
- With Microsoft Hololens 2
- For use in machine construction industry





Examples from PBE: RePILL

- „RePill“ - HoloLens Sharing Application



The Research Projects

IBIS5A: Wednesday 8:15 - 9:45, Room 1-236

IBIS5A: Wednesday 10:00 - 11:30, Room 1-236

IBIS5B: Wednesday 11:45 - 13:15, Room 1-236

IBIS5B: Thursday 8:15 - 9:45, Room 1-248

EBIS5: Thursday 14:15 - 15:45, Room 1-248 (Stefan Resch)

Please note

- **We** determine the research topics
  - Specific competences, research interests, laboratories, and equipment
  - We have an idea what original research is and what could be published
  - You do not have time to conduct an initial research
- Teams are **free to choose the following fields and topics**
  - You choose a topic, but you are free to design your study (of course you choose the best)
  - **Teams can do the same topic**
    - But focus on different aspects of the research question
- **No change of groups or topics after the first presentation**
- We will create groups after your first presentation

< PROJECT PROPOSAL >

- < PROJECT DESCRIPTION >

Questions?

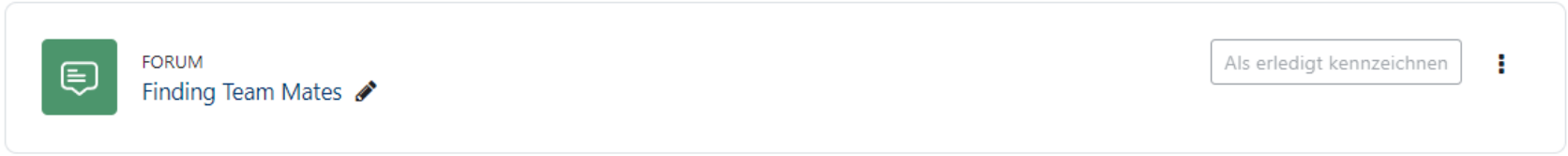
Project Discussion

Tasks next Time (TNT)

- **Find a group** (3 people, no more, no less)
- **Choose a topic** (you can pick up the proposals presented)
- **Find** and **read three papers** on that topic (check out your proposals)
- **Write a problem statement** (PDF, title, names, 150-200 words, submit in Moodle)
- **Give a kick-off presentation next time** (PDF, 5 slides)
  - **Title**: Project & You (1 slide)
  - **Background**: Motivation & problem (1 slide)
  - **Related Work**: What has been done by previous work (1 slides)
  - **Your Research Question** (1 slides)
  - **Method**: How do you want to answer the question? (1 slide)

Find a group

- **Online**
  - <ENTER LINK>



- **Offline**
  - Talk with real people

Example of a Problem Statement

- Authors….
- Title: Effect of Gender on the Perception of Avatar Hands in Virtual Reality
- Text: Displaying the user's hand as the primary body part for interaction enables natural user interactions with the virtual world and has different effects on interaction. For example, Argelaguet et al. [1] found that hand realism has an influence on the sense of agency, which is stronger for less realistic virtual hands. A study by Lin and Jörg [2] showed that the sense of ownership increases for human virtual hands. However, it is unclear whether and how the human-likeness of user controlled virtual hands influence the perceived sensation of presence [3] in VR. Furthermore, it is unknown if virtual hands are perceived differently by men and women, especially when avatar hands from another gender are used. Therefore, we want to conduct a user study to investigate the effect of realism and gender on the perception of presence.

[1] Ferran Argelaguet, Ludovic Hoyet, Michaël Trico, and Anatole Lécuyer. 2016. The role of interaction in virtual embodiment: Effects of the virtual hand representation. Proceedings - IEEE Virtual Reality 2016-July (2016), 3–10. DOI: http://dx.doi.org/10.1109/VR.2016.7504682

[2] Lorraine Lin and Sophie Jörg. 2016. Need a Hand?: How Appearance Affects the Virtual Hand Illusion. In Proceedings of the ACM Symposium on Applied Perception (SAP '16). ACM, New York, NY, USA, 69–76. DOI: http://dx.doi.org/10.1145/2931002.2931006

[3] Bob G. Witmer and Michael J. Singer. 1998. Measuring Presence in Virtual Environments: A Presence Questionnaire. Presence: Teleoperators and Virtual Environments 7, 3 (1998), 225–240. DOI: http://dx.doi.org/10.1162/105474698565686

Example of a Problem Statement

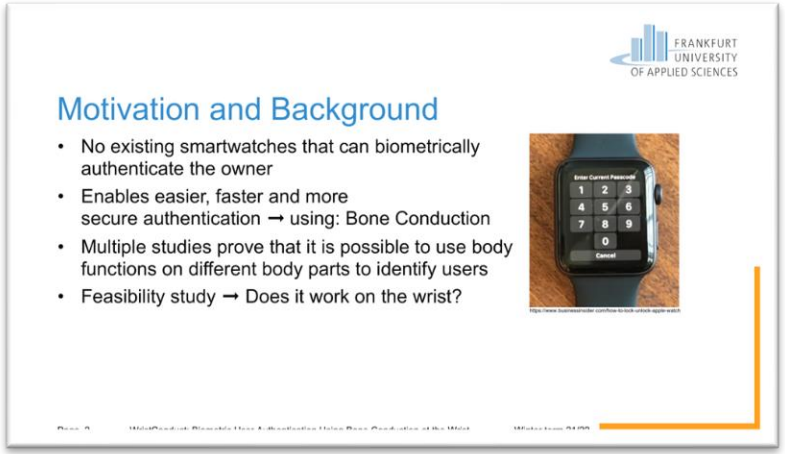
- Authors….
- Title: The Effects of Full-Body Avatar Movement Predictions in VR using Neural Networks
- Text: Motion tracking technologies and avatars in virtual reality (VR) showing the movements of the own body enable high levels of presence and a strong illusion of body ownership (IBO) [1]. However, any motion tracking or VR headset suffers from latency, which can cause motion sickness in users [2]. To overcome latency, previous work suggests to user prediction algorithms that can not only compensate system latency but also predict future movements. For example, linearly extrapolated movements can induce a “lighter weight” sensation [3], however, objective findings about the user performance while using sophisisticated neural networks able to predict the own movements in VR or input measures are currently unknown. In a standardized input performance task and a full-body gaming experience, we aim to investigate the effects of full-body avatar movement predictions using neural networks in VR.

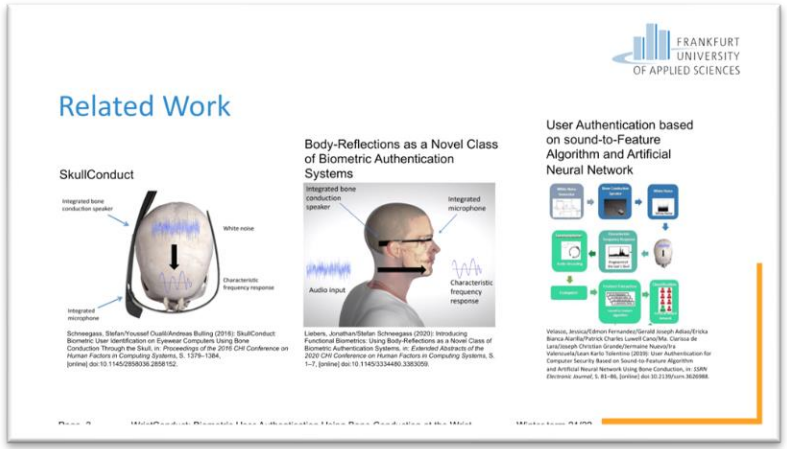
[1] Andrea Serino, Adrian Alsmith, Marcello Costantini, Alisa Mandrigin, Ana Tajadura-Jimenez, and Christophe Lopez. 2013. Bodily ownership and selflocation: Components of bodily self-consciousness. Consciousness and Cognition 22, 4 (2013), 1239 – 1252. https://doi.org/10.1016/j.concog.2013.08.013

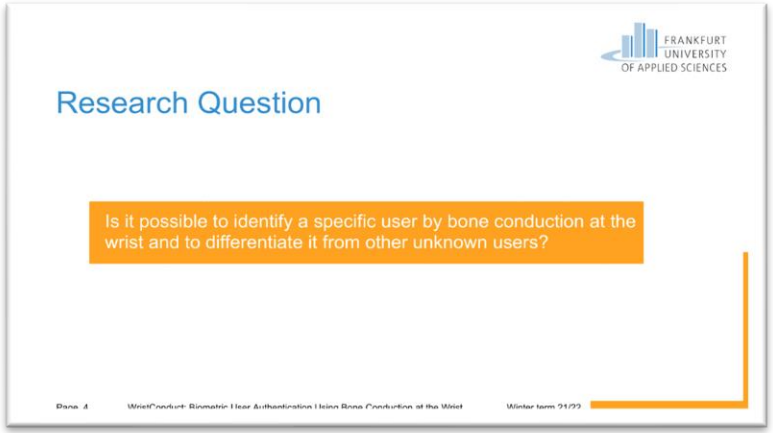
[2] Sotaro Shimada, Yuan Qi, and Kazuo Hiraki. 2010. Detection of visual feedback delay in active and passive self-body movements. Experimental Brain Research 201, 2 (2010), 359–364. https://doi.org/10.1007/s00221-009-2028-6

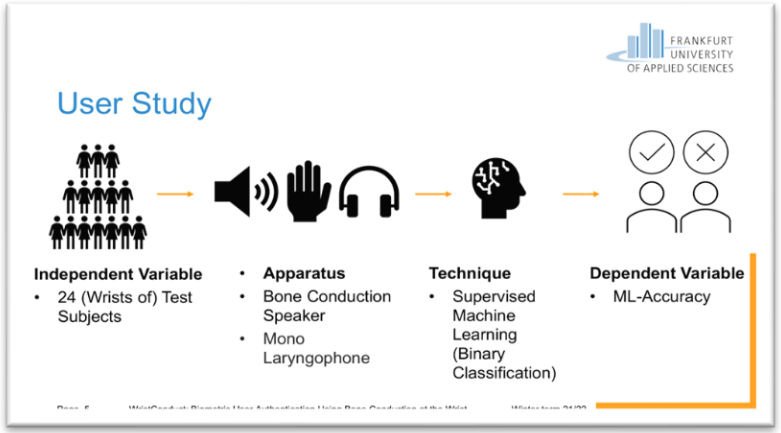
[3] Shunichi Kasahara, Keina Konno, Richi Owaki, Tsubasa Nishi, Akiko Takeshita, Takayuki Ito, Shoko Kasuga, and Junichi Ushiba. 2017. Malleable Embodiment: Changing Sense of Embodiment by Spatial-Temporal Deformation of Virtual Human Body. Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI ’17 (2017), 6438–6448. https://doi.org/10.1145/3025453.3025962

Example of a Kick-Off Presentation



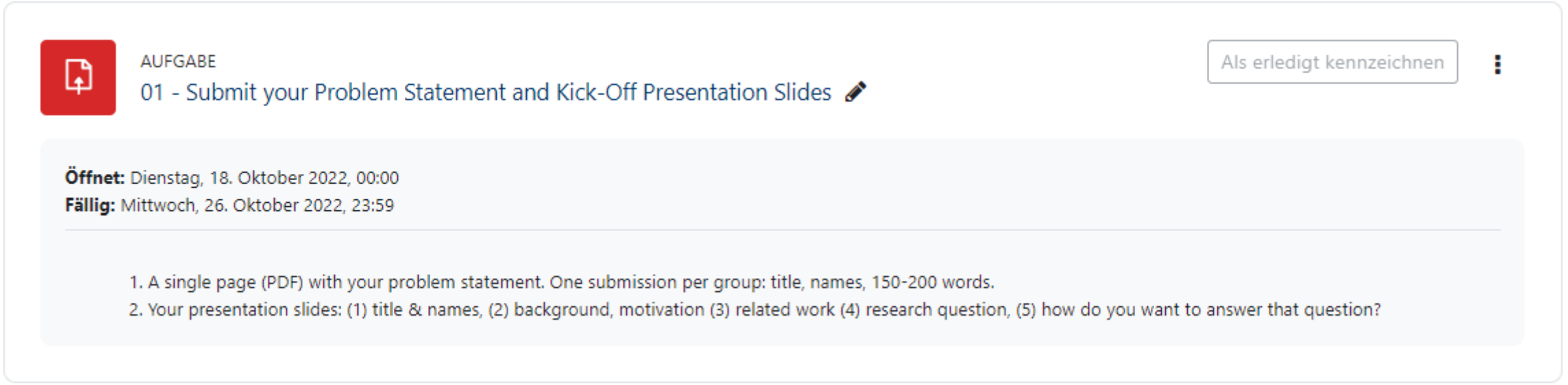






Moodle Submission

- Submit 2 PDFs until Oct 26:
  - A single page (PDF) with your problem statement. One submission per group: title, names, 150-200 words.
  - Your presentation slides (PDF): (1) title & names, (2) background, motivation (3) related work (4) research question, (5) how do you want to answer that question?



Questions?