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WIRTSCHAFTS-PSYCHOLOGIE

Fakultät für Psychologie

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Raising task state awareness in teams by means of Augmented Reality

Lisa Thomaschewski, Cedrik Rosinski, Timo Lietke

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Automation and Human factors Integration

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Prof. Dr. Annette Kluge, Chair Work, Organizational and Business Psychology, Faculty of Psychology, Ruhr-Universität Bochum

What we are interested in

Taskwork → **Teamwork** → **Organization**

Skill acquisition and retention
→The threat of skill decay
→ Effects of refresher trainings

Cognitive Readiness for **non-routine/abnormal** situations
→Information overload
→ Task overload

Training for Decision Making under stress
→ Stress exposure training
→ Training for Surprise
→ Task Technology Fit and technical support (App for Fault Diagnosis)

Team Training for High Responsibility Teams and performance under stress („Team performance breakdowns“)
•Training for adaptability
•Task reprioritization
•Task allocation
•Mutual support
•Back up behavior

- Safety Management in High Reliability Organisationen
- Organizational Learning from Errors
- Organisational Forgetting (adaptation to information overload)
- Stressors as antecedence for safety related rule violations („work safe tension“)

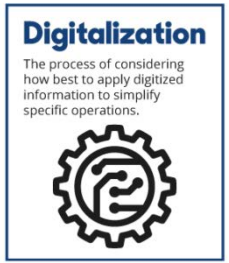
Agenda

- Introduction: **Digital Realities** for task work and team work
- Augmented Reality, Augmented Virtuality & Virtual Reality
- Their potential to support learning, transfer and daily work
- General Challenges in **team work**
- Digital Assistance for team coordination
- Task state awareness as a specific challenge
- Possible solutions and first results from 2 pretest

Digital Realities

Digitization, Digitalization & Digital Transformation

- **Digitization**: Transitioning from analog to digital-> e.g. from hard copies to e-checklists
- **Digitalization**: Making digitized information work for the organization-> processes reengineering by using **all available** data (Internet of Things/ IoT, Sensors, real time data…)
- **Digital transformation:** Taking advantage of digitalization to create completely new business concepts, e.g. by using AI, AR, etc…



Anna Irniger
29 November 2017

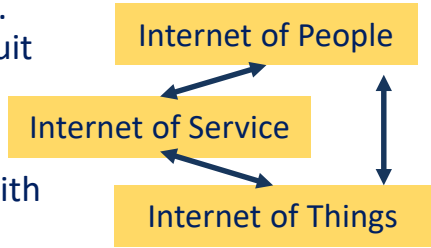
https://www.coresystems.net/blog/difference-between-digitization-digitalization-and-digital-transformation, retrieved 19.08.2019

Enablers of Digital transformation

Briefing
September 2015
European Parliament

….depends on a number of new and innovative technological developments:

- The application of **information and communication technology (ICT)** to digitize information and integrate systems at all stages of product creation and use (including logistics and supply), both inside companies and across company boundaries;
- **Cyber-physical systems** that use ICTs to monitor and control physical processes and systems. These may involve embedded **sensors**, intelligent **robots** that can configure themselves to suit the immediate product to be created, or **additive manufacturing** (3D printing) devices;
- **Network communications** including wireless and **internet technologies that serve to link machines, work products, systems and people**, both within the manufacturing plant, and with suppliers and distributors;
- **Simulation**, modelling and **virtualisation** in the design of products and the establishment of manufacturing processes;
- Collection of vast quantities of **data**, and their analysis and exploitation, either immediately on the factory floor, or through **big data** analysis and **cloud computing**;
- Greater ICT-based support for human workers, including robots, **augmented reality** and **intelligent tools**.



https://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf

Examples of Augmentation

ThyssenKrupp Elevator
https://www.youtube.com/watch?v=8OWhGiyR4Ns

Characteristics of Task work & Team work

HRO Task Work Characteristics – I

Couplings and interconnections *require the operator to* ***simultaneously process the interplay of cross-coupled variables*** *in order to either assess a process state or predict the dynamic evolution of the plant*

Dynamic effects *require the operator to mentally* ***process and envisage the change rates of cross-coupled variables*** *and to develop sensitivity for the* ***right timing*** *of decisions in order to be successful*

Non-transparency *requires the operator to work with* ***more or less abstract visual cues*** *that need to be* ***composed into a mental representation*** *and need to be compared with the operator's mental model*

Kluge, A., Nazir, S. & Manca, D. (2014). Advanced Applications in Process Control and Training Needs of Field and Control Room Operators, IIE Transactions on Occupational Ergonomics and Human Factors, 2:3-4, 121-136, DOI: 10.1080/21577323.2014.920437

Kluge, A. (2014) *The acquisition of knowledge and skills for taskwork and teamwork to control complex technical systems. A cognitive and macroergonomics Perspective*. Springer: Dortrecht.

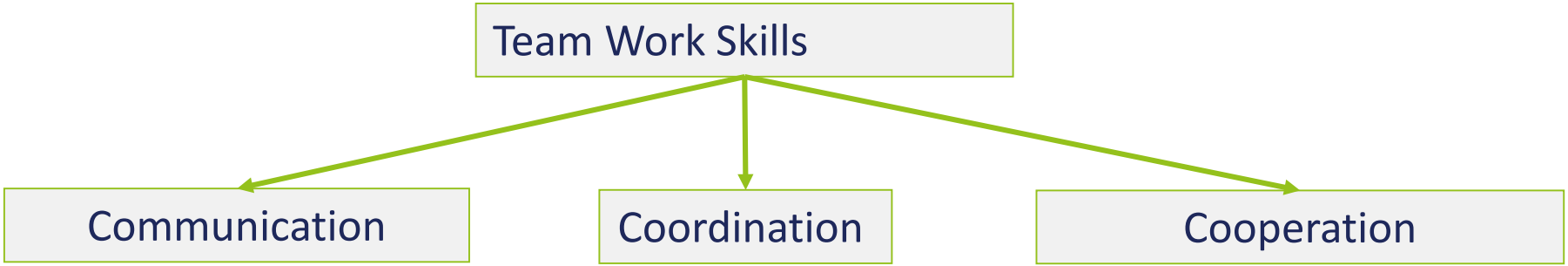
HRO Task Work Characteristics - II

Multiple or conflicting goals *require the operators either to* ***balance management intentions or to decide on priorities*** *in case of goal conflicts in the decision making process,* e.g. *which course of actions to take*

Crew coordination complexity incorporates small crews and supervisors, who are responsible for overall system operations *and calls for the operators to* ***concurrently interact with team members in order to orchestrate individual actions into a coordinated flow of actions to either assess the situation or choose a course of actions***

Kluge, A., Nazir, S. & Manca, D. (2014). Advanced Applications in Process Control and Training Needs of Field and Control Room Operators, IIE Transactions on Occupational Ergonomics and Human Factors, 2:3-4, 121-136, DOI: 10.1080/21577323.2014.920437

Team work requirements



- Information exchange
- Phraseology
- Closed-loop communication

Knowledge requirements

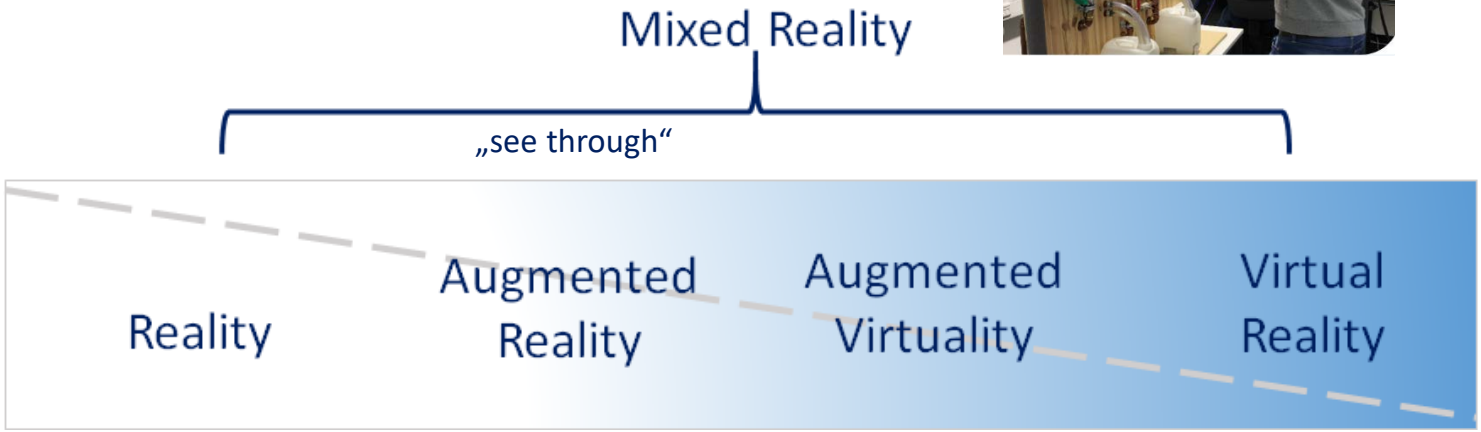
- Goal related knowledge
- Task related knowledge
- Process related knowledge
- Team related knowledge
- Shared SA
- Shared Shared Mental Model

- Mutual performance monitoring
- Back up behavior
- Adaptability
- Team orientation
- Collective efficacy
- Mutual Trust
- Team cohesion

Wilson, K.A., Salas, E. & Andrews, D.H. (2010). Preventing errors in the heat of the battle: formal and informal learning strategies to prevent teamwork breakdowns. In D.H. Andrews, R.P. Herz, & M.B. Wolf (Eds.), *Human factors issues in combat identification* (pp. 1-28). Aldershot, United Kingdom: Ashgate.

The Reality-Virtuality Continuum

Mixed Realities- a continuum



AR **supplements** reality

Ideally, it would appear to the operator that virtual and real objects coexist in the same space *(„Who framed Roger Rabbit?“)*

AV **augments the virtual system** through real inputs

VR **replaces** reality, completely immerses user inside a synthetic environemt (Azuma, 1997)

Milgram, P. & Kishino, F. (1994). A taxonomy of mixed reality visual displays. *IEICE TRANSACTIONS on Information and Systems*, *77*(12), 1321-1329.
Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators & Virtual Environments*, *6*(4), 355-385.

Augmented Reality

AR-Support of cognitive porcesses in work contexts

Percieve

Recall

Act

Augmented Reality

- AR is a set of innovative and effective Human Computer Interaction (HCI) techniques
- **AR enriches the way that users experience the real world by embedding virtual objects to coexist and interact with reral objects in the real world** (Wang et al, 2016)
- E.g. Google Glas, Pokemon go, Museums....head worn versus hand held tables, smartphones...
- Has been applied successfully in areas such as medicine, maintenance and repair, cultural heritage, and education
- Has been used for planning, design, ergonomics assessment, operation guidance and training, by creating an augmentedenvironment where virtual objects (instructions, visual aids, and industrial components coexist and interact with real objects and environment.
- AR is one of the nine enabling technologies that paoer the digital transformation supported by Industry 4.0 (Davies 2015, Uva et al., 2018)
- AR uses **head worn display** for hands free work (but can also be projections)

Wang, X., Ong, S. K., & Nee, A. Y. (2016). A comprehensive survey of augmented reality assembly research. *Advances in Manufacturing*, *4*(1), 1-22.
Uva, A. E., Gattullo, M., Manghisi, V. M., Spagnulo, D., Cascella, G. L., & Fiorentino, M. (2018). Evaluating the effectiveness of spatial augmented reality in smart manufacturing: a solution for manual working stations. *The International Journal of Advanced Manufacturing Technology*, *94*(1-4), 509-521.

https://www.youtube.com/watch?v=0m67O1Em7dY

Augmented Reality

AR- aiming to provide digital **intuitive instructions** at the same time as operators are working on the task (Oliviera et a., 2014)

With AR, artificial information about the environemt and its objects can be **overlaid on the real world** in order to enhance the operator's perception of reality (Syberfeldt et al., 2015)

An AR system has

- the ability to combine real and virtual objects
- ability to **register (align) real and virtual objects** with each other,
- ability to run interactively, in three dimension, and in real time

(Kreveln and Poelman, 2010, Azuma , 1997)

Act

Augmented Reality

Examples from AZUMA „Real Desk“

- AR **adds** objects to the real world but also can **remove** objects (e.g. to hide irrelevant information or cues)
- AR might apply to all senses not just sight (Azuma, 1997) focus on blending real and virtual images and graphics but AR can be extended to include **sound** (adding synthetic directional 3 D sound) or **tactile feedback** (gloves that provide tactile feedback and augment real forces in the environment)

-> in the following I speak mainly about **see through HMD**- lets the user see the real world with virtaul objects super imposed by optical technologies (Azuma, 1997)

Examples from Azuma (1997)

- Medicine
- Manufacturing an repair (Thyssen Krupp Film)
- Annotation and Visualization
- Robot Path Planning
- Military - Striker II

Figure 1: Real desk with virtual lamp and two virtual chairs. (Courtesy ECRC)

Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators & Virtual Environments*, *6*(4), 355-385.

AR **Applications**

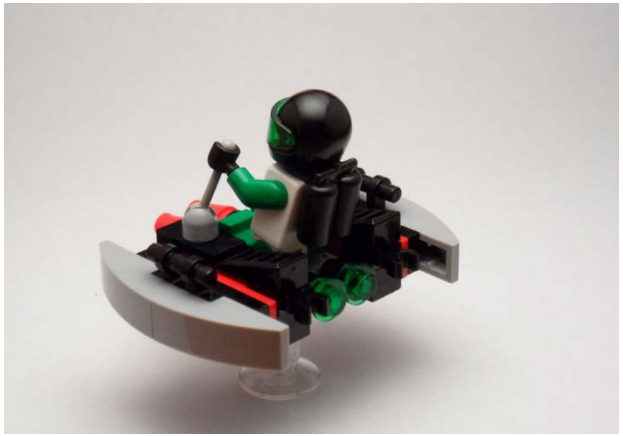
- AR for Hazard Identification and risk recognition , sensining, analysing and extracting potential danger
- AR for **safety training and education**: visualization-based training to experience-based training in safety (Li et al., 2018)
- AR for **safety inspection and instruction**: AR for recognizing safety risks, for inspection, supervision and strategizing
- AR for high risk equipment operation

Recall

Li, X., Yi, W., Chi, H. L., Wang, X., & Chan, A. P. (2018). A critical review of virtual and augmented reality (VR/AR) applications in construction safety. *Automation in Construction*, *86*, 150-162.

Military

https://www.google.com/search?client=firefox&q=Striker%20II%20Helmet



BAE Systems Striker 2 helmet with symbology and night vision imagery

http://www.miltechmag.com/2015/11/iitsec-2015-visualisation-systems.html

Striker II

https://www.youtube.com/watch?v=mdPylWKX6uA

AR for training of procedures

Ability to combine abstract concepts and 3 D spatial information in the context of real-world objects makes AR an ideal tool for training in situations which requires manupulation of objetcs, , e.g. assembly or maintenance tasks (Westerfield et al., 2015)

- Capacity to **deliver hands-on training where users recieve visual instructions** in the context of real world objects
- Combining **work and maintenance instruction and safety instruction** in AR (Tatić & Tešić, 2017).
- Intelligent tutoring systems (ITS) provides customized instruction to each student
- The integration of ITS and AR creates new possibilities (Westerfield et al., 2015)
- AR can **avoid the burden of fusing information displayed on several screens** (Ruano et al., 2017)

Westerfield, G., Mitrovic, A., & Billinghurst, M. (2015). Intelligent augmented reality training for motherboard assembly. *International Journal of Artificial Intelligence in Education*, *25*(1), 157-172.
Ruano, S., Cuevas, C., Gallego, G., & García, N. (2017). Augmented Reality Tool for the Situational Awareness Improvement of UAV Operators. *Sensors*, *17*(2), 297.
Tatić, D., & Tešić, B. (2017). The application of augmented reality technologies for the improvement of occupational safety in an industrial environment. *Computers in Industry*, *85*, 1-10.

Collaborative AR

Collaborative AR (Billinghurst & Kato, 2002)

AR can be used to **ennhance a shared physical work space**, presence of spatial cues for face-to-face and remote collaboration

AR system **promotes information exchange and SA** for teams (Lukosch et al, 2015) eg.

- remote user AR support,
- local user AR support
- localization and mapping
- shared memory space

Lukosch, S., Lukosch, H., Datcu, D., & Cidota, M. (2015). Providing information on the spot: Using augmented reality for situational awareness in the security domain. *Computer Supported Cooperative Work (CSCW)*, *24*(6), 613-664.
Billinghurst, M., & Kato, H. (2002). Collaborative augmented reality. *Communications of the ACM*, *45*(7), 64-70.

Augmented Virtuality

Augmented Virtuality

Augments the virtual system through real inputs (AV), (Borsci et al. 2015), if **tactile feedback** is required

Augmented Virtuality (AV) = integrating real operating elements in a virtual environment for Head-mounted Displays (Neges et al., 2018)- **seperate visual and haptic perception**

Borsci, S., Lawson, G., & Broome, S. (2015). Empirical evidence, evaluation criteria and challenges for the effectiveness of virtual and mixed reality tools for training operators of car service maintenance. *Computers in Industry*, *67*, 17-26.
Neges, M., Adwernat, S., & Abramovici, M. (2018). Augmented Virtuality for maintenance training simulation under various stress conditions. *Procedia Manufacturing*, *19*, 171-178.

Virtual Reality

VR Applications

VR is to generate immersive environments from which users can experience unique insights into the way the real world works (Li et al., 2018)

Their potential to support learning, transfer and daily work

Adaptive Intelligent System

Interactive **digital assistance systems** for an augmented operator

Examples of the new possibilities for **employee support are assistance systems** that support employees individually in carrying out work steps **based on their qualifications or competences** already acquired.
-> enables job rotation through on-the-job training and execution support (Prinz, Kreimeier & Kuhlenkötter, 2017)
->also known as **situational employee qualification** (Kreggenfeld & Kuhlenkötter, 2016).
->supports employees,

- even **without many years of experience** at a workplace
- special work activities or
- with **problems that occur rather rarely**, to carry out these activities within a defined standard despite a lack of routine (Kreggenfeld & Kuhlenkötter, 2016).

In the case of situational support, a systematic comparison of requirements and employee-related knowledge and skill requirements takes place in the work process or in the process chain.
-> particularly relevant in the heterogeneous and complex work
-> supports the employees on-the-job, which can be used more flexibly with the assistance system (Kreggenfeld & Kuhlenkötter, 2016).

Recall

Kreggenfeld, N., & Kuhlenkötter, B. (2016). Situative Mitarbeiterbefähigung in der Industrie 4.0. *ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb, 111(10)*, 658-661.
Prinz, C., Kreimeier, D., & Kuhlenkötter, B. (2017). Implementation of a learning environment for an Industrie 4.0 assistance system to improve the overall equipment effectiveness. *Procedia Manufacturing, 9,* 159-166.

Challenges in learning and executing complex tasks

High interinsic load – due to learning task complexity (challenging for working memory capacity during learning)

High cognitive load while learning

High extraneous load – due to inappropriate training methods

e.g. split attention effect

High mental work load while working – individual task
High mental workload e.g. due to changing rules that need to be recalled an applied

High mental work load while task execution

High additional mental workload due to team work requirements – team task

The integration of task work and teamwork skills is a concurrent task demand. It shares elements of a dual task, which requires time-sharing and attention allocation.

Challenges in learning and executing complex tasks

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High cognit
while learn
vork load
ecution

AR can help visualize dynamic effects (e.g. prediction)
AR can visualize conflicting goals
AR can superimpose virtual elements that are intransparent
AR can superimpose checklist items to reduce memory requirements
AR can be used as a situative assistance for non-routine situations
Ar can superimpose information from different screens
AR can serve as a coordination assistance system

High extraneous loa
inappropriate trainin

e.g. split attention effect

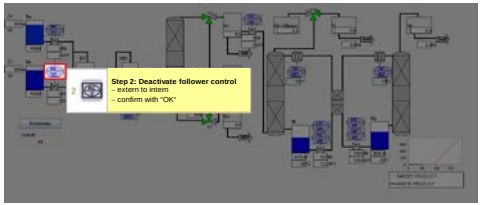
work due to
team work requirements – team task

The integration of task work and teamwork skills is a concurrent task demand. It shares elements of a dual task, which requires time-sharing and attention allocation.

An example for an digital assistance (overlay)

Frank, B. & Kluge, A. (2018) Cued skill recall: The effect of gaze guiding to support of complex cognitive skill recall to reduce errors and retain performance. *International Journal of Industrial Ergonomics,* 67, September 2018, 123-134. https://doi.org/10.1016/j.ergon.2018.05.007

AR to support Recall

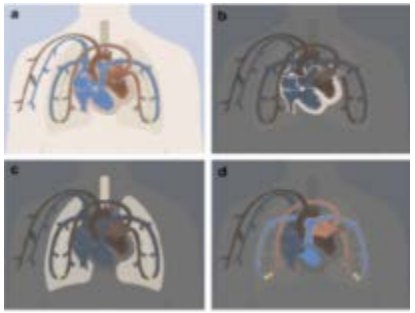


Developed Gaze Guiding

(Kluge & Frank, 2014)

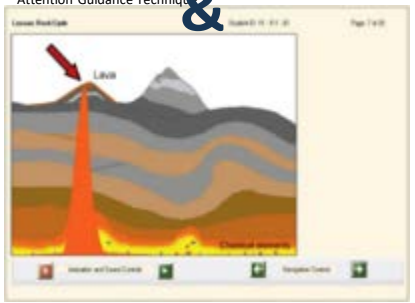
Recall support with Gaze Guiding *as cued recall*

- **Dynamic computer-based job aids** have been used for the learning of skills and can be applied through various methods, such as the Attention Guidance Technique and Visual Cueing
- Combination of Attention Guidance Technique, Visual Cueing and further textual information (De Koning, Tabbers, Rikers & Paas, 2010; Lin & Atkinson, 2011)



Attention Guidance Technique

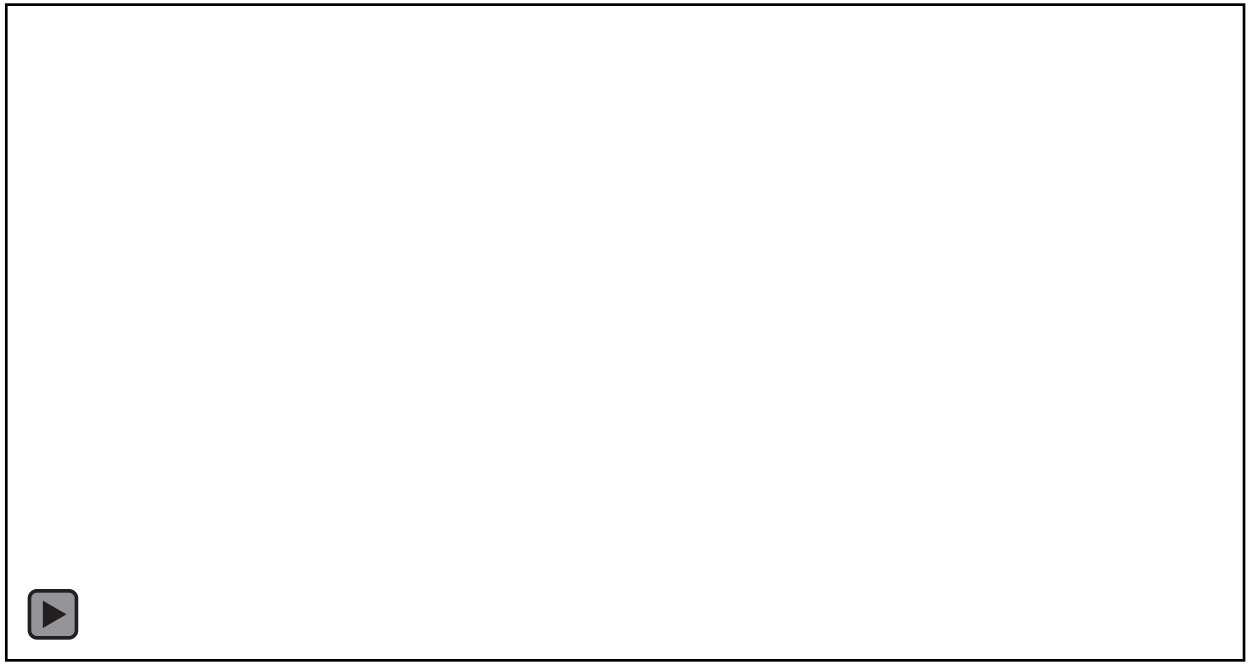
&



Visual Cueing

Gaze Guiding- Demonstration

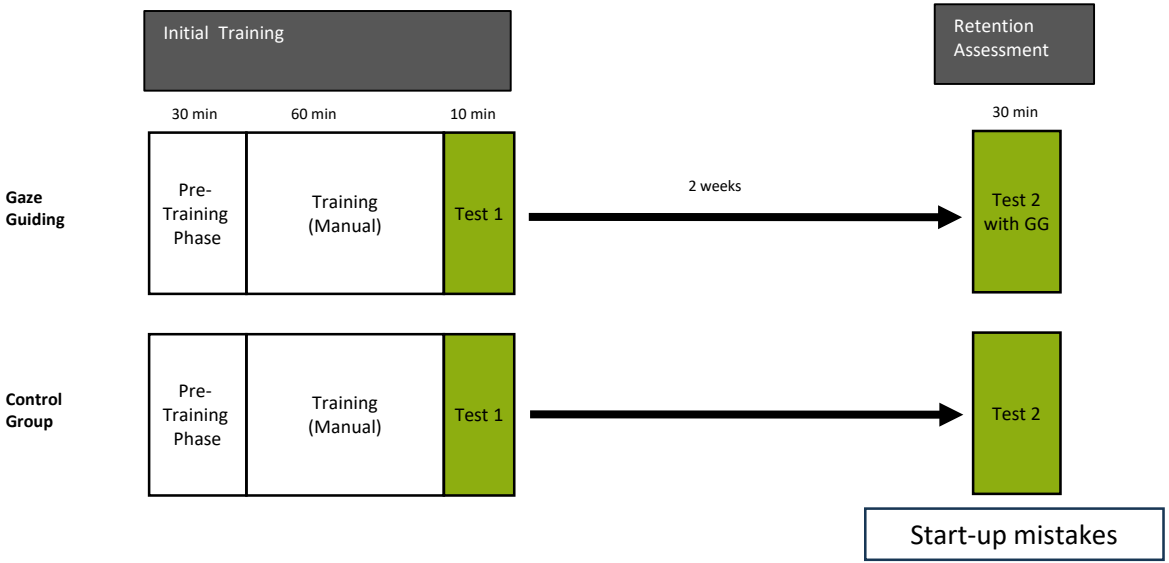
http://www.aow.ruhr-uni-bochum.de/fue/gazeguiding.html.de



Method Exp. 1-3: Participants & Procedure

Participants

Experiment 1: Fix	Experiment 2: Parallel	Experiment 3: Contingent
N=36 (15 female)	*N*=40 (13 female)	*N*=35 (12 female)
Age: 21.97 (2.43, 18-28)	Age: 22.65 (3.56, 18-31)	Age: 22.74 (2.81, 19-30)



- Weyers, B., Frank, B., Frank, Bischof, K. & Kluge, A (2015). Gaze guiding as Support for the Control of Technical Systems. *International Journal of Information Systems for Crisis Response and Management, Special Issue on Human Computer Interaction in Critical Systems,* 7(2), 59-80.

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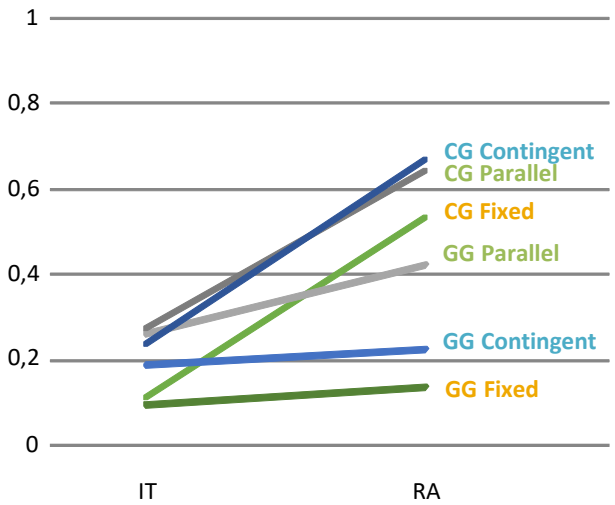
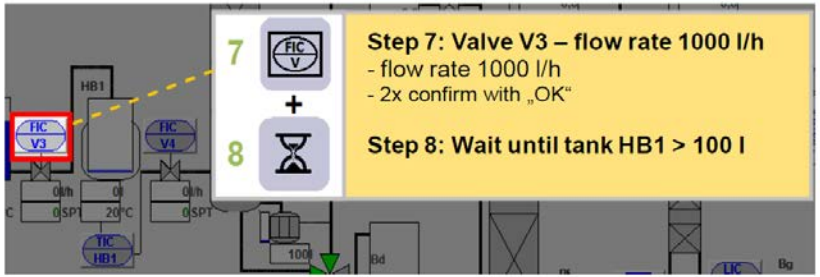
Results: Hypothesis

Start-up mistakes



**All participants of the Gaze Guiding-group used the gaze guiding-tool at least 1x



Exp. 1: Fixed sequence task

Interaction of time and group:
$F(1,34)=27.28$, $\mathbf{p<.001}$, $n^2_p=0.05$

Exp. 2: Parallel sequence task

Interaction of time and group:
$F(1,38)=4.96$, $\mathbf{p=.032}$, $n^2_p=0.12$

Exp. 3: Contingent sequence task

Interaction of time and group:
$F(1,32)=17.60$, $\mathbf{p<.001}$, $n^2_p=0.04$

All experiments: GG and CG handled as one group each: GG vs CG

Interaction of time and group:
$F(1,108)=29.77$, $\mathbf{p<.001}$, $n^2_p=0.22$

Frank, B. & Kluge, A. (2017). Cued Recall with Gaze Guiding – Reduction of Human Errors with a Gaze-Guiding Tool. In K.S. Hale, & K.M. Stanney (Eds.), Advances in Neuroergonomics and Cognitive Engineering (pp. 3-16). Heidelberg: Springer.

Digital assistance for team work

RUHR-UNIVERSITÄT BOCHUM
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&

Universität Trier
Human+Computer Interaction

RUB

Gefördert durch
DFG Deutsche Forschungsgemeinschaft
Fördernummer KL2201/7-1

The impact of ambient awareness on temporal coordination of dispersed teams

RUHR-UNIVERSITÄT BOCHUM

Lisa Thomaschewski, Thomas Schweiß, Arnulf Schüffler, Cedrik Rosenski, Yuen Cheong Law Wan, Benjamin Weyers, Annette Kluge

Objective of the study

-> to build and empirically investigate the effects of **temporal coordination artifacts**

->that support the **temporal coordination** of teamwork of

->**spatially dispersed team**s in production settings

->by means of enhanced **task state awareness**.

Spatially dispersed teams

Spatially dispersed teams

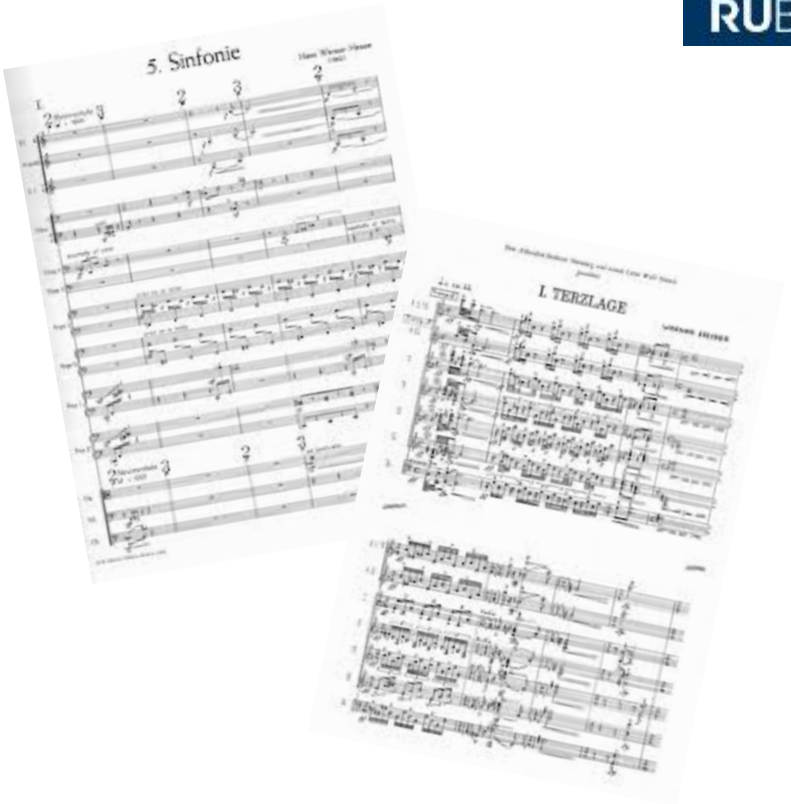
Temporal Coordination

Temporal coordination (Badram, 2000)

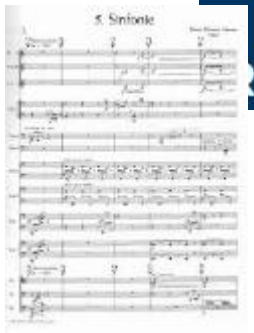
1)the correct **sequencing** of joint action (knowing and executing what comes first, second, third, etc.),

2) the correct **timing** (knowing the best moment to execute the task, not too early and not too late, e.g. Hollnagel, 1998), and

3) the **adaptation** of dynamic effects as variables in the team's context (Kluge et al., 2018)



Kluge, A., Borisov, N., Schüffler, A. & Weyers, B. (2018). Augmented Reality to Support Temporal Coordination of Spatial Dispersed Production Teams. MCI-WS07: Virtual and Augmented Reality in Everyday Context (VARECo). Dresden 2018



Temporal Coordination

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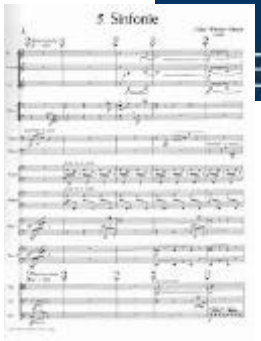
3) the adaptation of dynamic effects as variables in the team's context
(Kluge et al., 2018)

- timing errors, such as problems of synchronization,
- errors in judging durations,
- dealing with low levels of shared temporal cognition,
- errors in matching periods of time with bundles of activities (McGrath, 1991)

Kluge, A., Borisov, N., Schüffler, A. & Weyers, B. (2018). Augmented Reality to Support Temporal Coordination of Spatial Dispersed Production Teams. MCI-WS07: Virtual and Augmented Reality in Everyday Context (VARECo). Dresden 2018

Temporal Coordination



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"**not being on the same page**" (Mohammed & Nadkarni, 2014)

→ leads to disagreement about when to start and finish sub-tasks and to team members subscribing to different schedules and pacing (Gevers & Peeters, 2009)

Kluge, A., Borisov, N., Schüffler, A. & Weyers, B. (2018). Augmented Reality to Support Temporal Coordination of Spatial Dispersed Production Teams. MCI-WS07: Virtual and Augmented Reality in Everyday Context (VARECo). Dresden 2018

Task State Awareness

- Awareness of the task state (Kraut et al., 2002; Wallace, Scott, Stutz, Enns & Inkpen, 2009),
- ….which is the awareness of the current state of the collaborative task in relation to an end goal (Kraut et al., 2002).

Supported by

- Scripted coordination (Bardram, 2000),
- shared visual space (Fussell, Kraut & Siegel, 2000; Kraut, Gergle & Fussell, 2002; Sebanz et al, 2006; Vesper, Schmitz, Safra, Sebanz & Knoblich, 2016)
- Coordination Artifacts

Kluge, A., Borisov, N., Schüffler, A. & Weyers, B. (2018). Augmented Reality to Support Temporal Coordination of Spatial Dispersed Production Teams. MCI-WS07: Virtual and Augmented Reality in Everyday Context (VARECo). Dresden 2018

Central Proposition

AR technology → allows → superimposition of critical process states → leads to → ambient awareness → leads to → task state awarness → leads to → optimal temporal team coordination

Why AR?

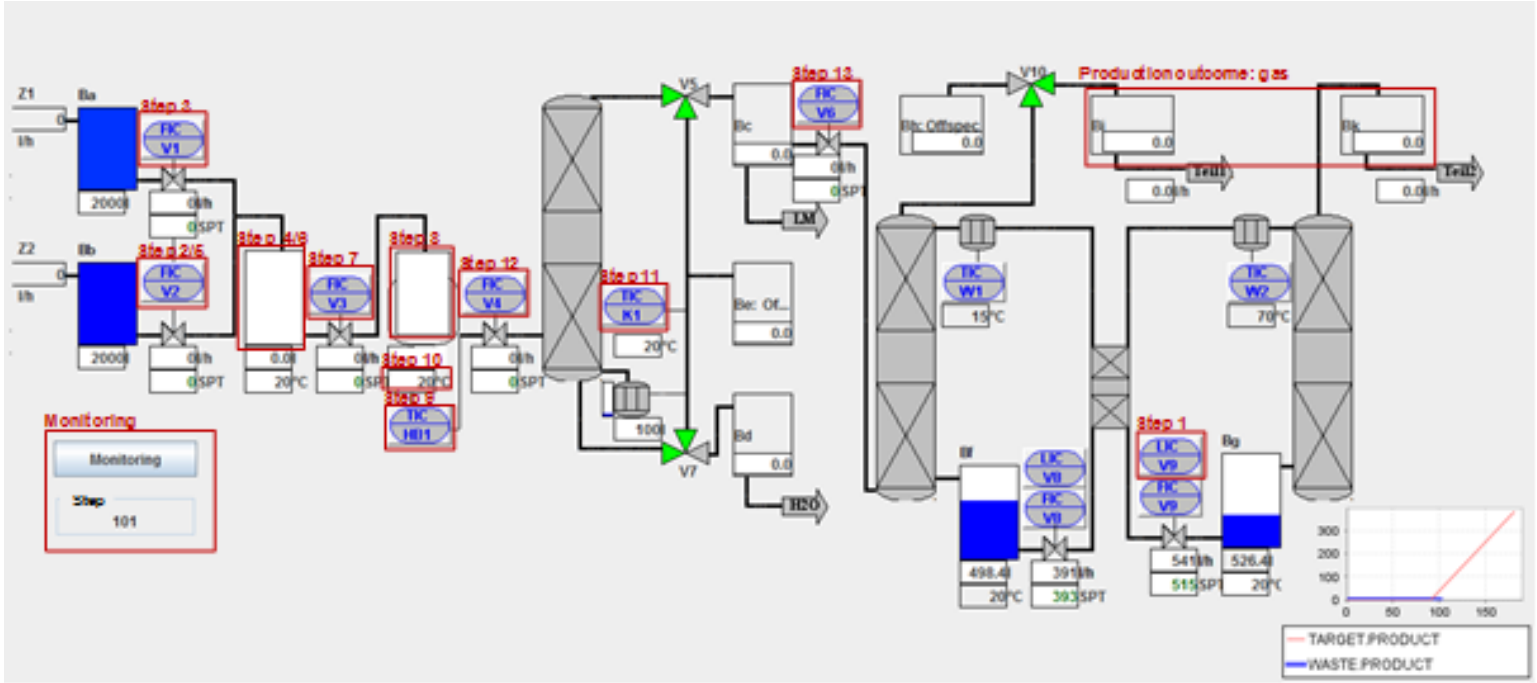
Peripheral & Ambient Awareness (Cadiz et al., 2002)

- "peripheral awareness interfaces: a class of awareness interfaces that seeks to provide awareness via software that resides in the user's peripheral attention".
- Awareness on Primary Displays: One area of peripheral awareness research examines methods for embedding peripheral information within a user's primary screen"

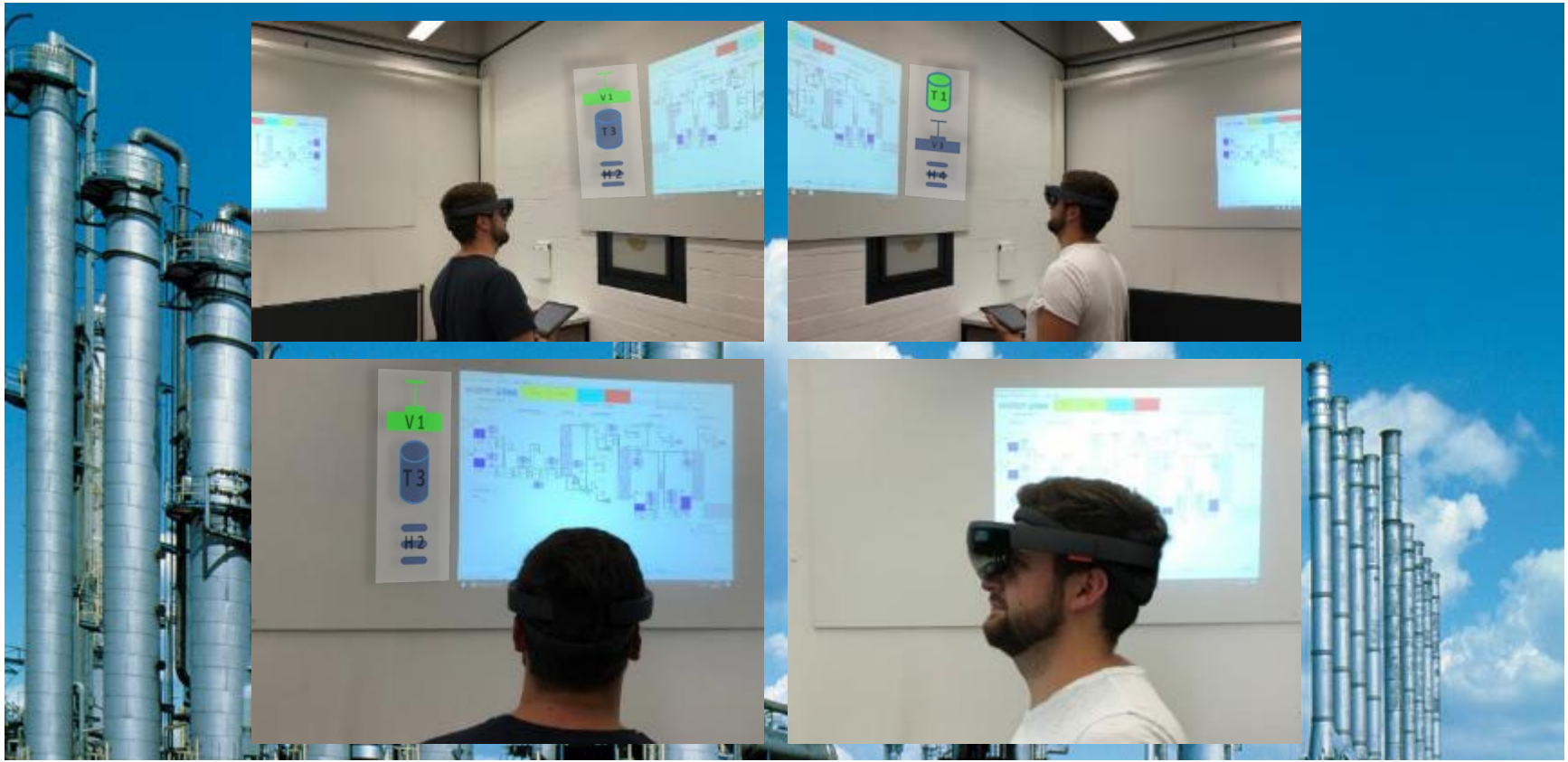
- "Team coordination and productivity can be enhanced if people can maintain better **awareness of the activities of the team and the events in the world** that may affect their team -especially with teams that have to work at different times and in different locations" (Streitz et al. 2003).
- **„Ambient devices present dynamic information in an at-a-glance manner and have low attentional requirements."** **(Downs, Plimmer & Hosking 2012)**

The realised use case

Individual and Team Task



The general Set-up


V1
T3
H2
T1
V1
T3
H2

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PSYCHOLOGIE

RUB


V1
T3
H2


T 1
V 3
H 4

Pretest- I

Design

Learning to use the HoloLens (15 min.) → Learning to operate AWA-Sim (TI only; 15 min.) → Operating AWA-Sim TT & TI parallel (5 times; 30 min.)

Measuring:
- general self-efficacy (Schwarzer & Jerusalem, 1999)
- Technology Usage Inventory (Kothgasser, et. al. 2013)
- Process / technical knowledge (Kluge & Frank, 2014)
- Collective orientation (Hagemann & Kluge 2017)

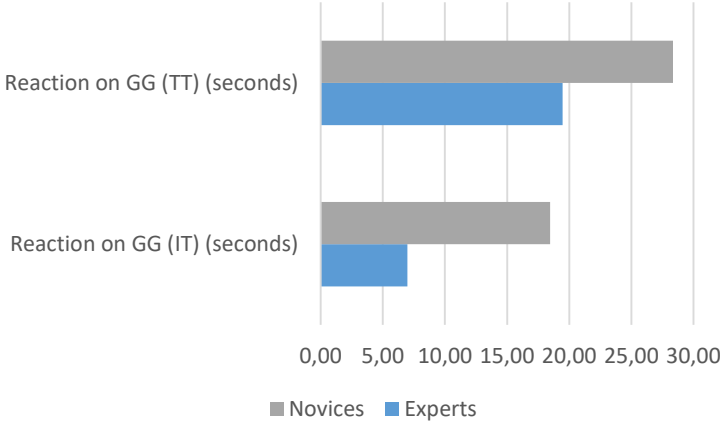
Measuring:
- Specific self-efficacy (Kluge, 2004)

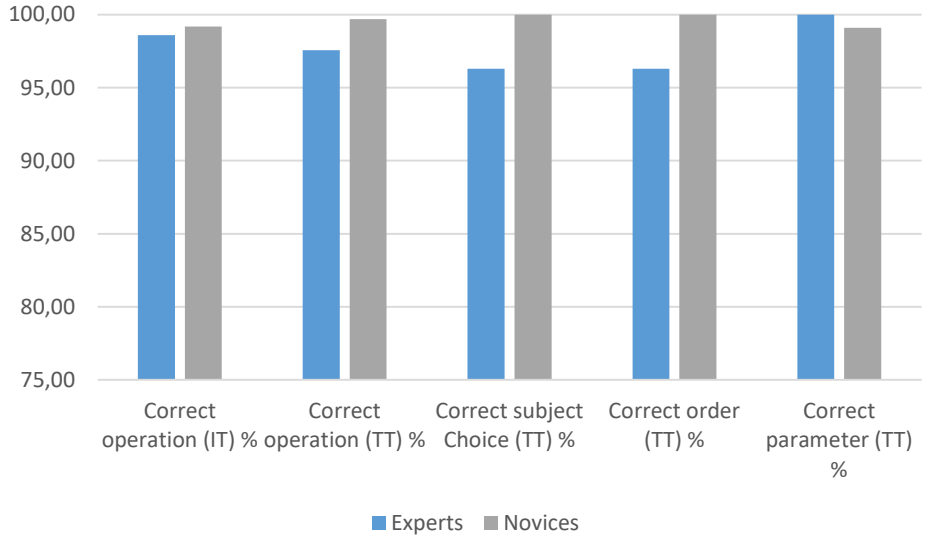
additional questionnaires

Participants:
Students (*n* = 11, female: 9, male: 2)
Including two female experts for the waste-water simulation

Schüffler, Rosenski & Liedtke, 2018

Results: Performance





Gaze Guiding (GG) and Ambient Awareness enable non-experts to work as **correctly** as experts

Gaze guiding and ambient awareness do not enable non-experts to work as fast as experts.

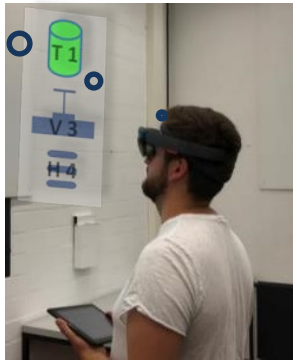
Subjective Measures

- Cognitive load (Klepsch, Schmitz and Seufert, 2017)
- Ambient superimposition evaluation (Weyers, Frank & Kluge, 2017)
- Gaze-Guiding usage questionaire (Weyers, Frank & Kluge, 2017)
- Ambient information questionaire (Haniff & Baber, 2003)
- Technology accecptance in AR settings (Wojciechowski, & Cellary, 2013)
- Technology acceptance model 3 (Venkatesh & Bala, 2008)
- Possession of technical objects (Schüffler, 2018)
- Technology experience (Mollenkopf et al, 2000)
- Technology attitude (Mollenkopf et al, 2000)
- Sociodemographic data

Extracts of Pre-Post Test Ratings on Impressions, Technology Accpetance etc.

Scale Range from 1 = totally disagree, 7 = totally agree

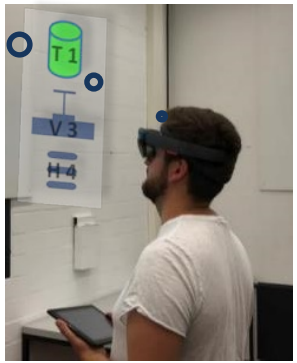
N = 10	M	SD
(Before) „I am curious to use the technology“	6.0	0.9
„The superimposition at the side are designed attractive“	4.14	1.1
„The superimpositions were helpful to operate the plant“	4.43	1.4
„The superimpositions at the side were disturbing“	*1.86*	*0.9*
„It was easy for me to operate the plant by using the Hololens“	4.4	1.01
„Working with the Hololens was boring“	*1.78*	*1.3*
„The Hololens helped me to execute the task more efficiently“	5.4	1.6
„I think the Hololens was usefull for supporting task execution“	6.0	1.0
„It takes not much mental effort to interact with the Hololens“	5.4	1.8



Extracts of Pre-Post Test Ratings on Impressions, Technology Accpetance etc.

Scale Range from 1 = totally disagree, 7 = totally agree

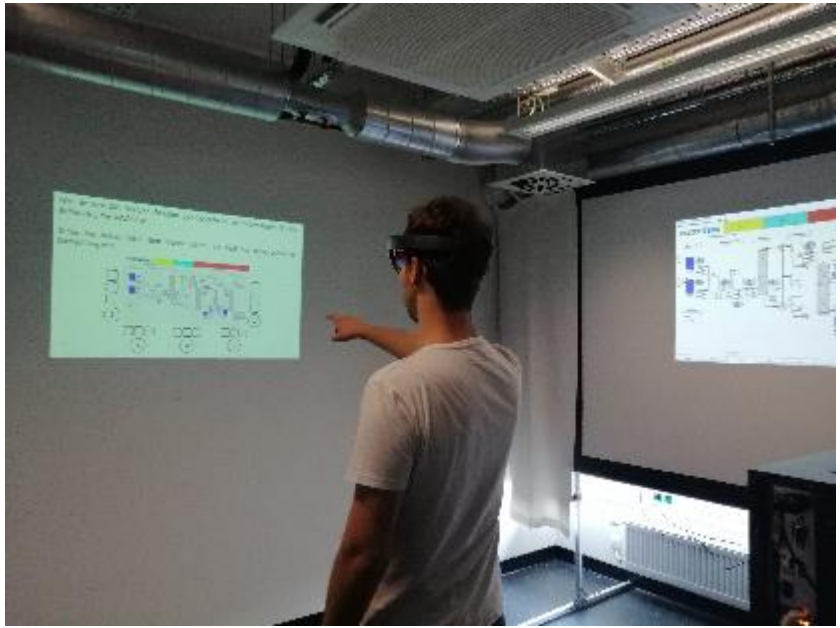
N = 10	M	SD
„I could perform my task with the Hololens well …		
….if no one would be there to explain the task“	4.78	2.1
… if some one explained to me the task first“	6.44	.72
… if I had experienced a similar task before“	6.44	.72
„I had fun using the Hololens“	5.4	1.2
„Results of using the Hololens are obvious“	5.8	.02



Pretest - II

How to augment?

Holodeck I and II



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PSYCHOLOGIE

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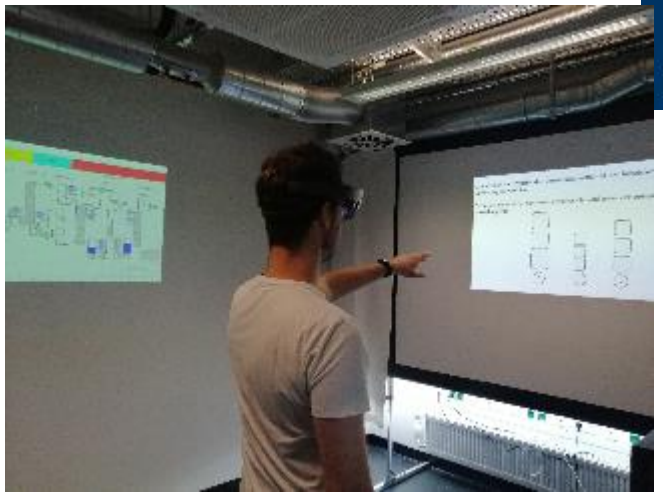
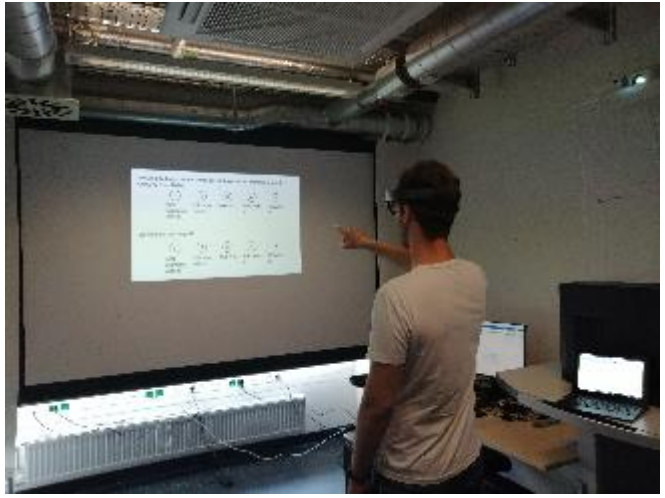
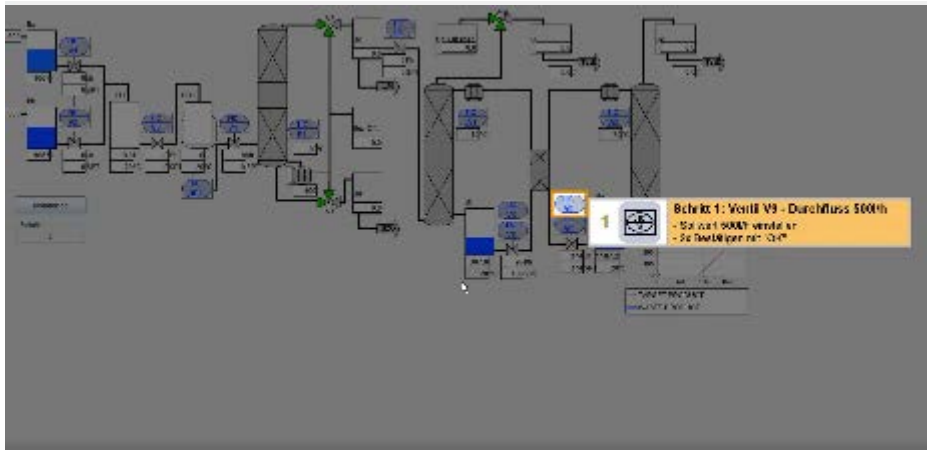




How to augment in an ambient way?

Team task
Individual task



Gaze Guiding Tool

Ambient Awareness Tool

Ambient Awareness Teamtask

Ambient Awareness Individual Task

UX Ambient Awareness

1. Evaluation of the most beneficial:

- Position (e.g. sideways or below the simulation)
- Distance (between objects and objects for simulation)
- Size of objects
- Object states (static or dynamic)

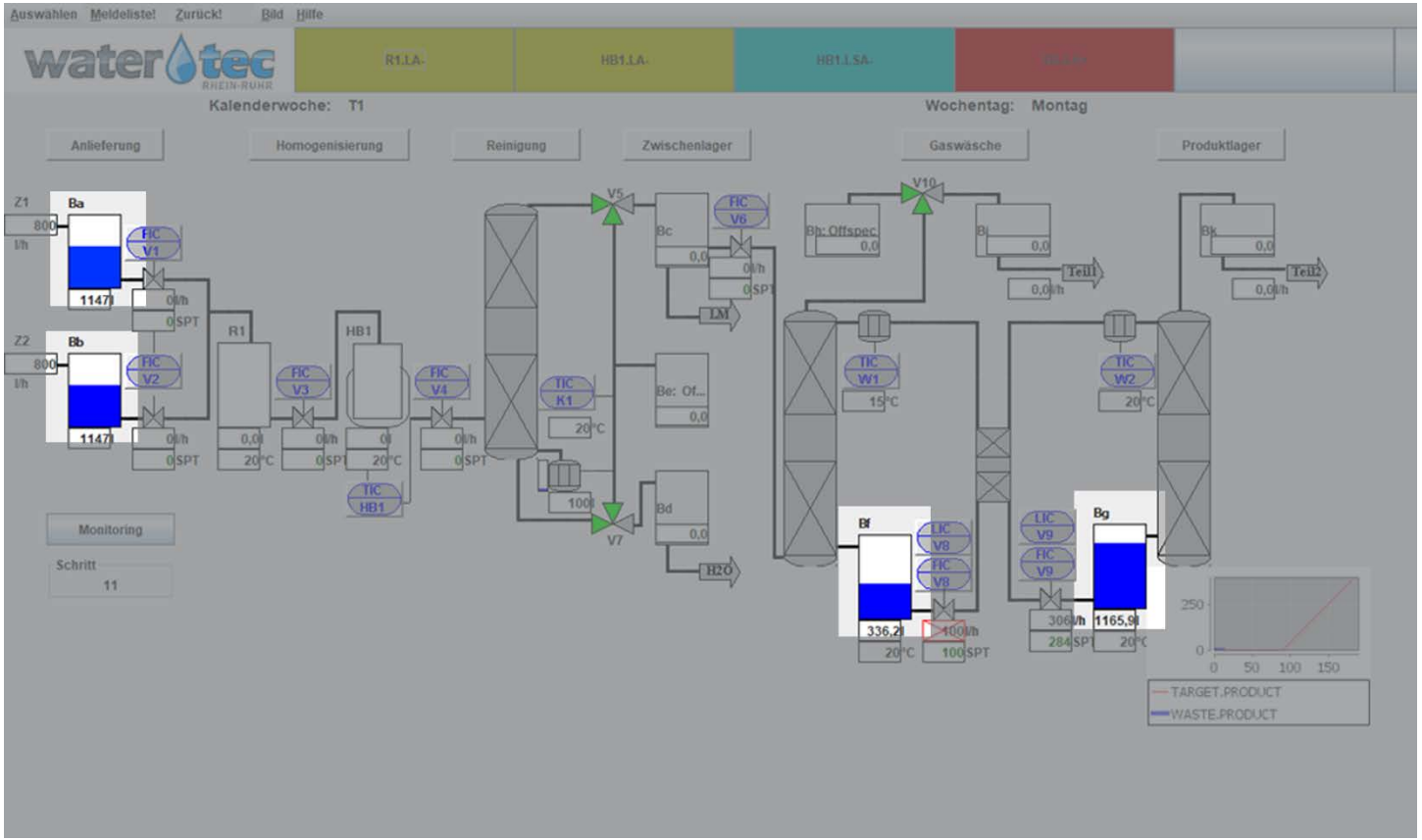
UX Ambient Awareness

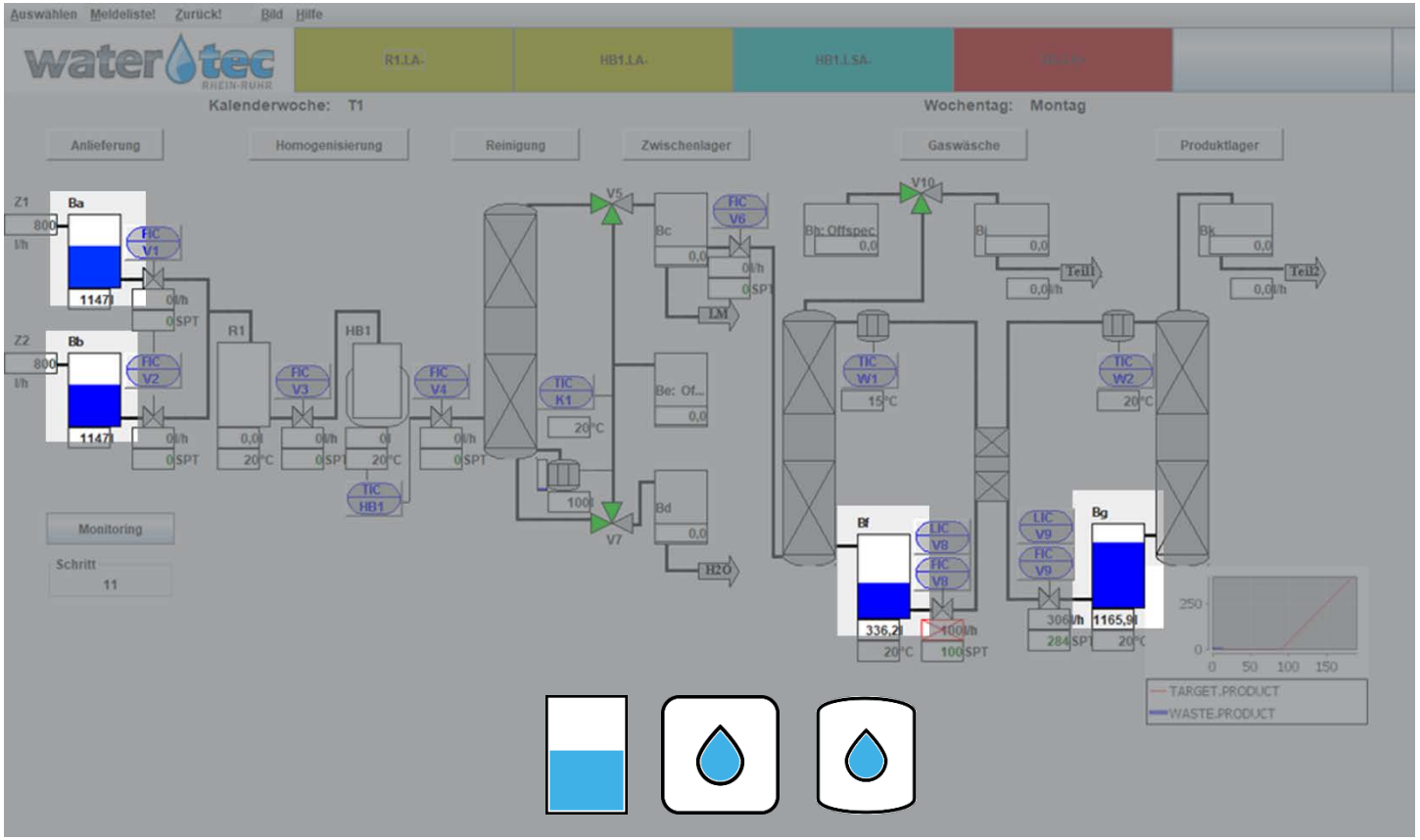
2. Evaluation of the design of the objects

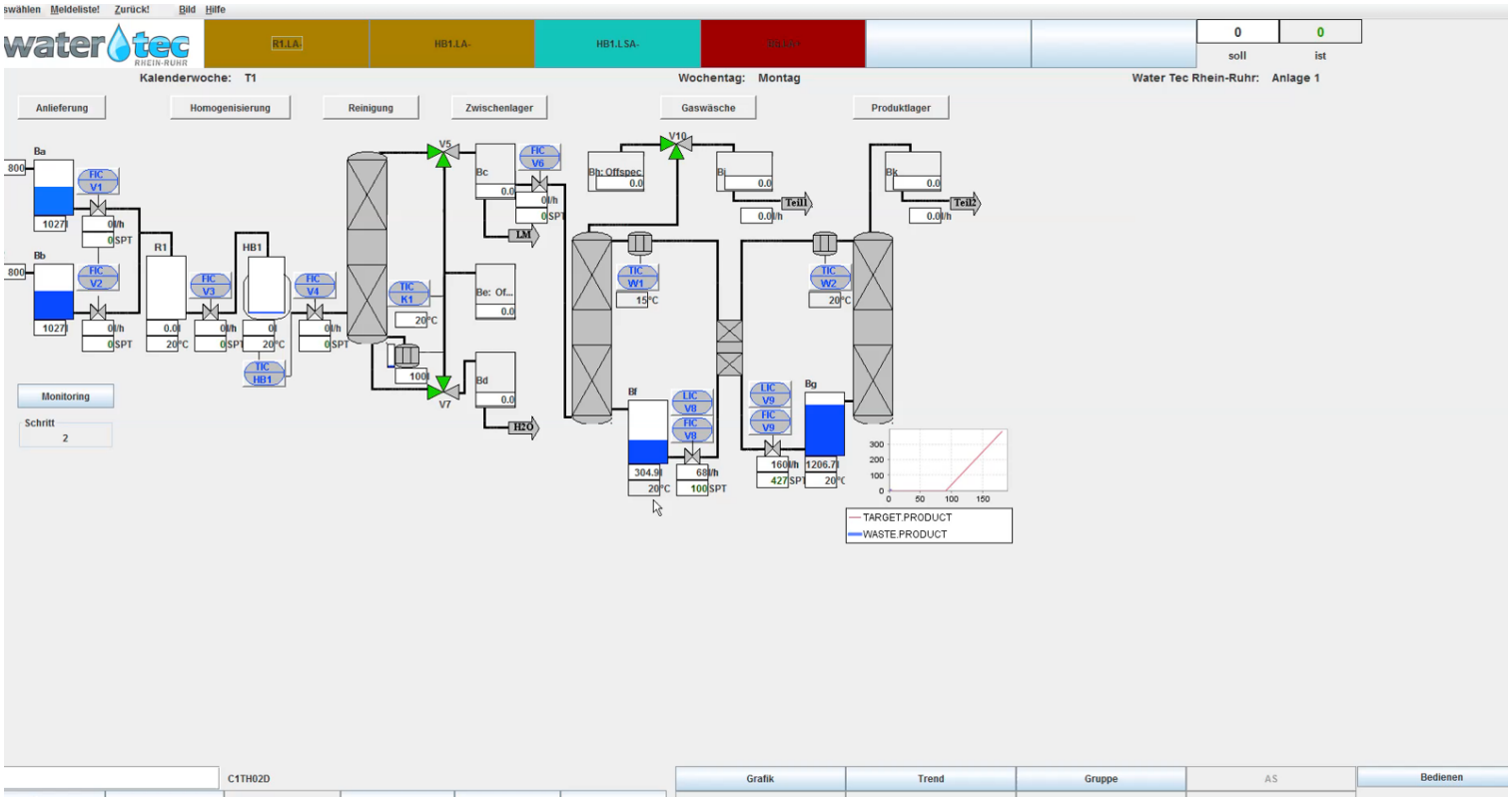
- 2D/ 2.5D/ 3D
- Degree of abstraction (to the object design of the simulation surface)
- colour
- transparency
- Surface


Project Phase I
laboratory
Project Phase II
online
Phase I:
Phase II:
Phase III:
4 – 6 weeks
Phase IV:
measurement of visual acquity
• stereoscopic vision (Lang, 1983)
• color blindness (Hrsg. Kuchenbecker & Broschmann, 2016)
general health questionnaire (Claßen, 2012)
sociodemographic questionnaire
AWASim preknowledge
standardized audio recorded explanation of the experimental background and procedure
introduction of the Microsoft HoloLens
usability evaluation
Simulator Sickness questionnaire (Kennedy, 1993)
user experience evaluation
• AttrakDiff (Hassenzahl, Burmester & Koller, 2003)
• User Experience Questionnaire (Laugwitz et al., 2006)
25 min
15 min
60 min
20-30 min

How should the tanks be displayed?




Auswählen Meldeliste! Zurück! Bild Hilfe
water tec
RHEIN-RUHR
Kalenderwoche: T1
Wochentag: Montag
Anlieferung
Homogenisierung
Reinigung
Zwischenlager
Gaswäsche
Produktlager
Monitoring
Schritt
11
TARGET.PRODUCT
WASTE.PRODUCT
1
2
3


swählen Meldeliste! Zurück! Bild Hilfe
water tec RHEIN-RUHR
R1.LA-
HB1.LA-
HB1.LSA-
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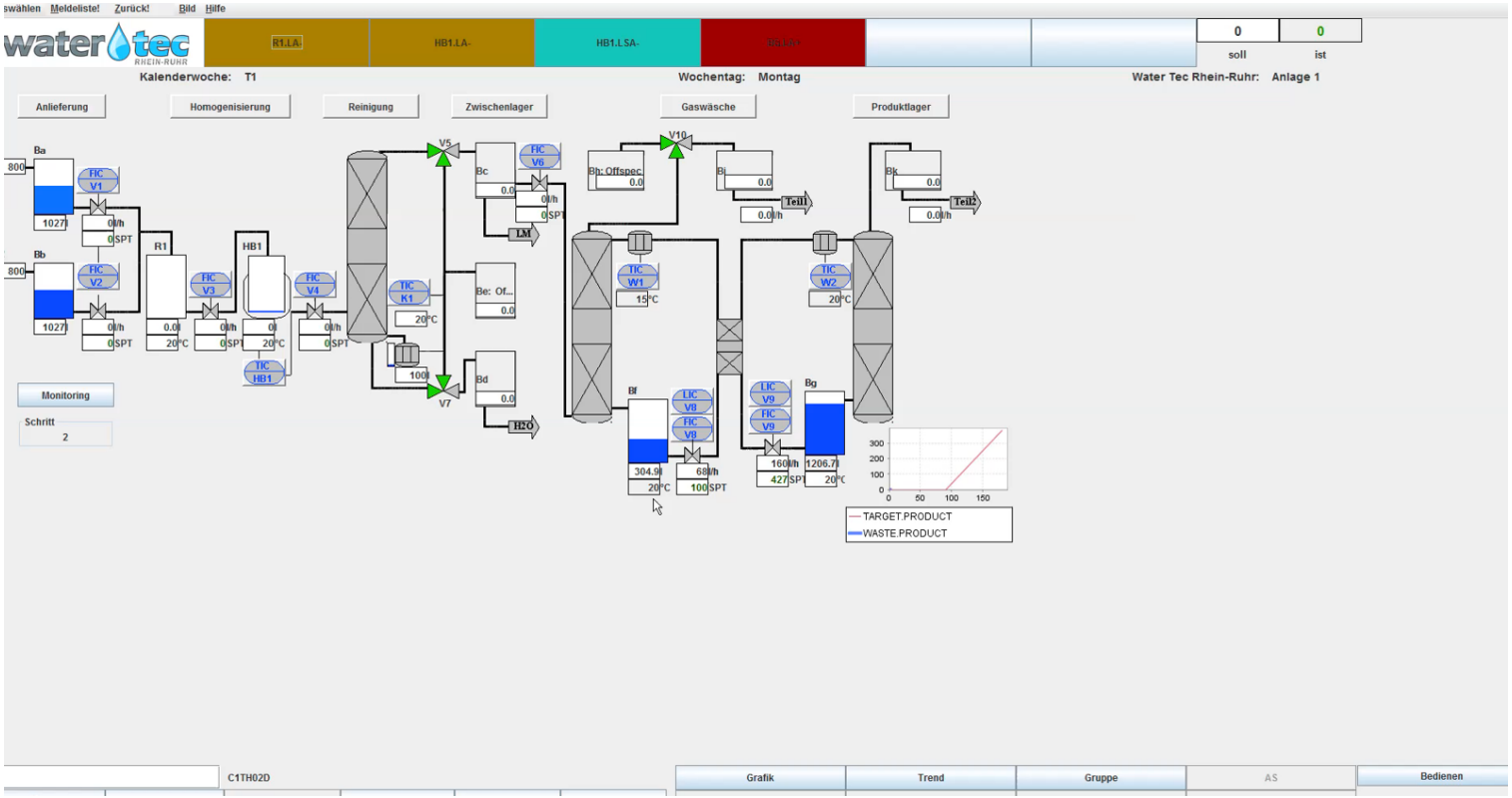
Kalenderwoche: T1
Wochentag: Montag
Water Tec Rhein-Ruhr: Anlage 1
Anlieferung
Homogenisierung
Reinigung
Zwischenlager
Gaswäsche
Produktlager
Ba
Bb
Bc
Bd
Be: Of...
Bf
Bg
Bh: Offspec
Bi
Bk
R1
HB1
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10
K1
W1
W2
LM
H2O
Teil1
Teil2
Monitoring
Schritt
2
TARGET.PRODUCT
WASTE.PRODUCT
C1TH02D
Grafik
Trend
Gruppe
AS
Bedienen


swählen Meldeliste! Zurück! Bild Hilfe
water tec RHEIN-RUHR
R1.LA-
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soll
ist
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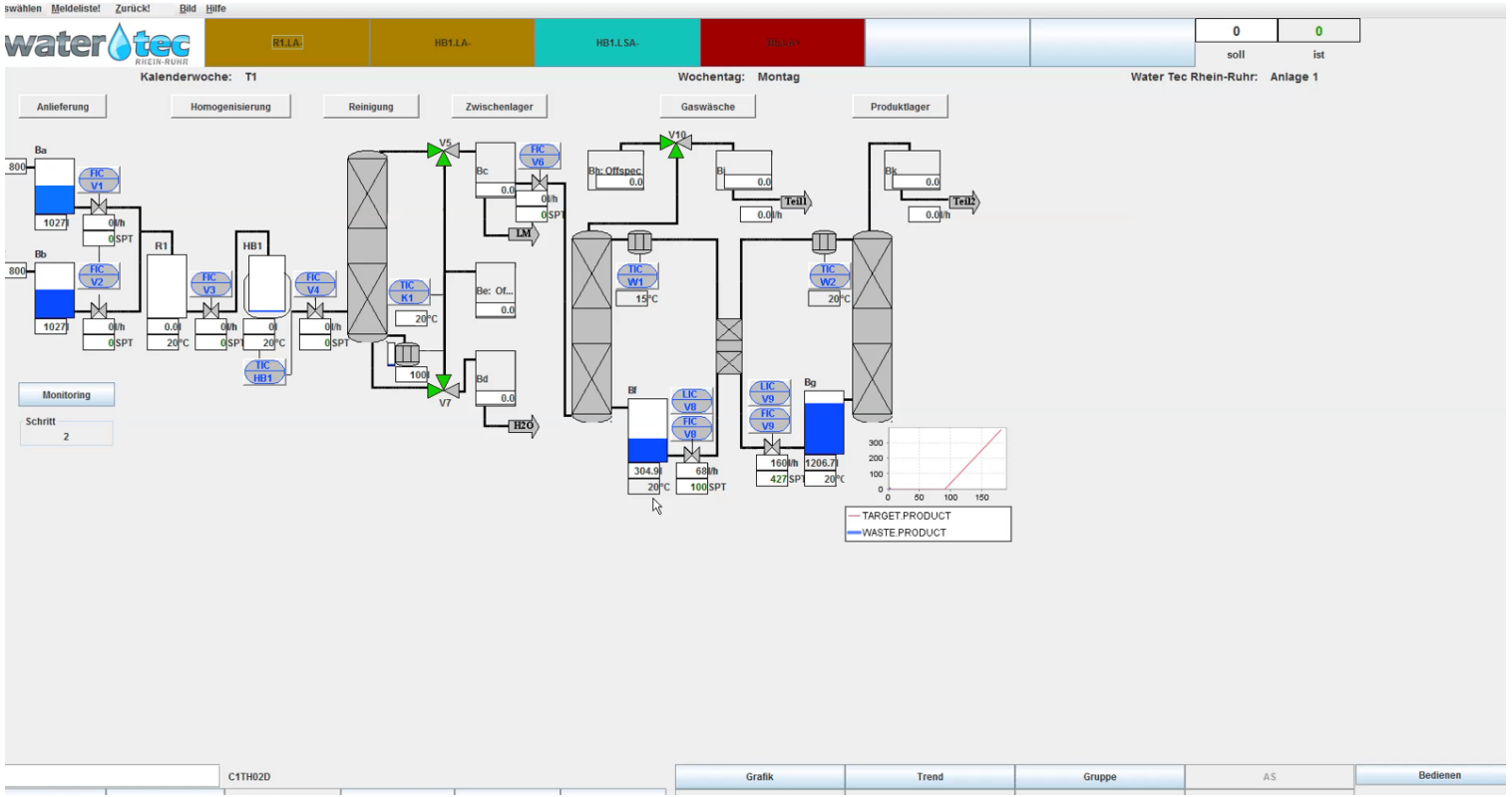
Bedienen


swählen Meldeliste! Zurück! Bild Hilfe
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R1.LA
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Kalenderwoche: T1
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Anlieferung
Homogenisierung
Reinigung
Zwischenlager
Gaswäsche
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Ba
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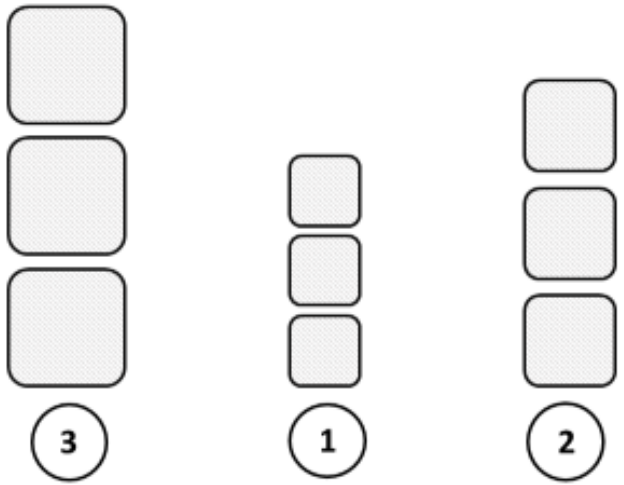
R1
HB1
Bc
Be: Of...
Bd
Bf
Bg
Bh: Offspec
Bi
Bk
Teil1
Teil2
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10
K1
W1
W2
LM
H2O
Monitoring
Schritt
2
TARGET.PRODUCT
WASTE.PRODUCT
C1TH02D
Grafik
Trend
Gruppe
AS
Bedienen

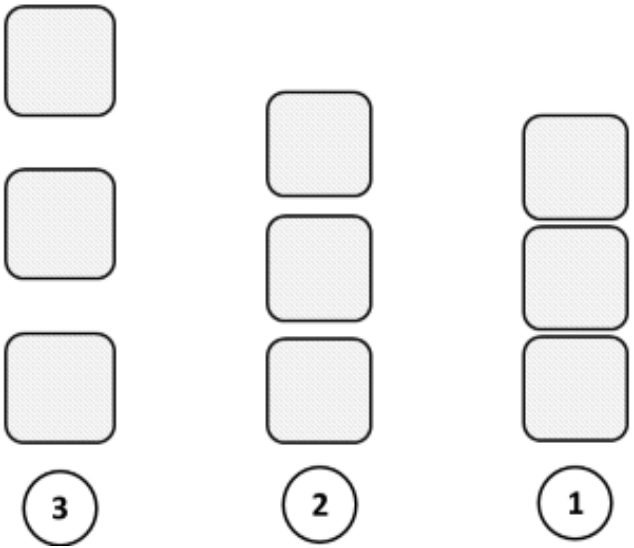
In which size should the objects be displayed?

Teilen Sie hierzu bitte dem Versuchsleiter die Zahl unter der entsprechenden Darstellung mit.



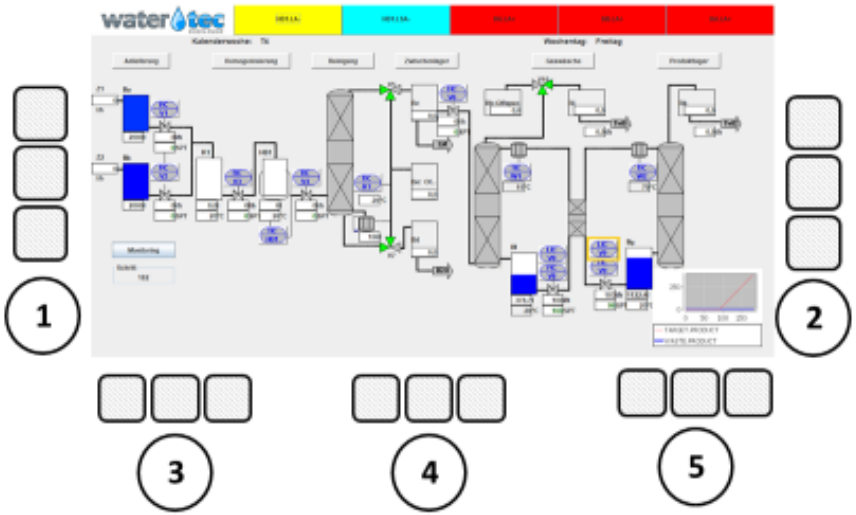
In which distance to each other should the objects be displayed?

Teilen Sie hierzu bitte dem Versuchsleiter die Zahl unter der entsprechenden Darstellung mit.



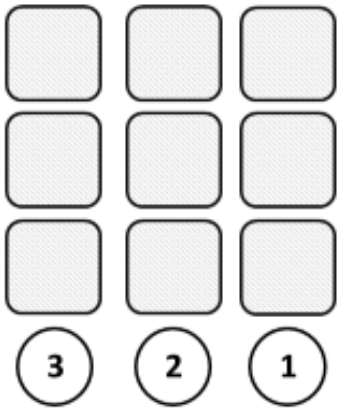
Where should the objects be displayed?

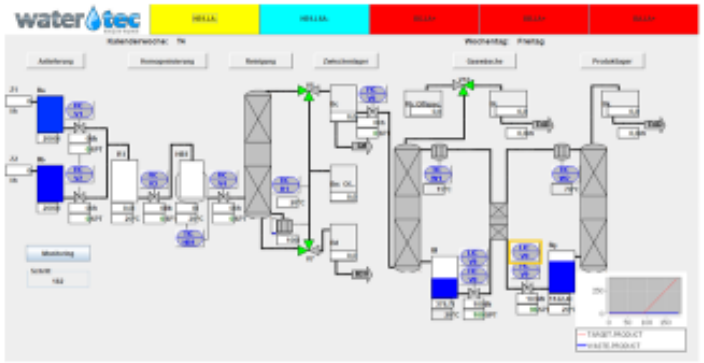
Teilen Sie hierzu bitte dem Versuchsleiter die Zahl der entsprechenden Darstellung mit.



In which distance to the screen should the objects be displayed?

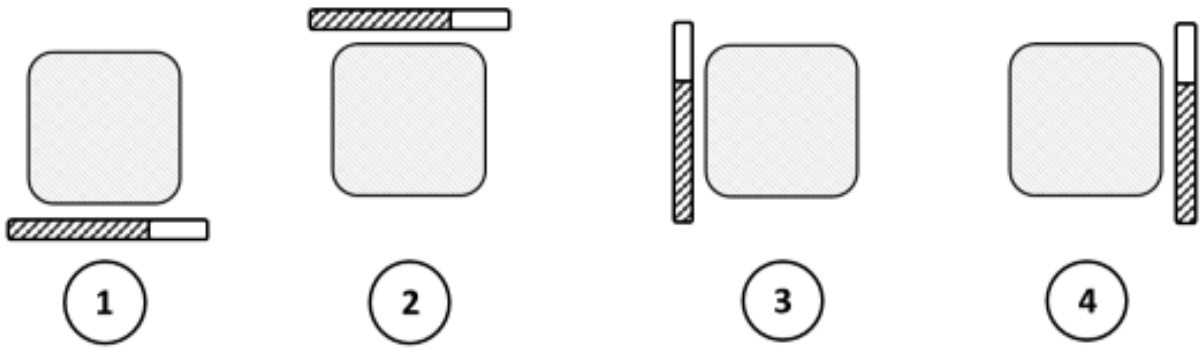
Teilen Sie hierzu bitte dem Versuchsleiter die Zahl der entsprechenden Darstellung mit.

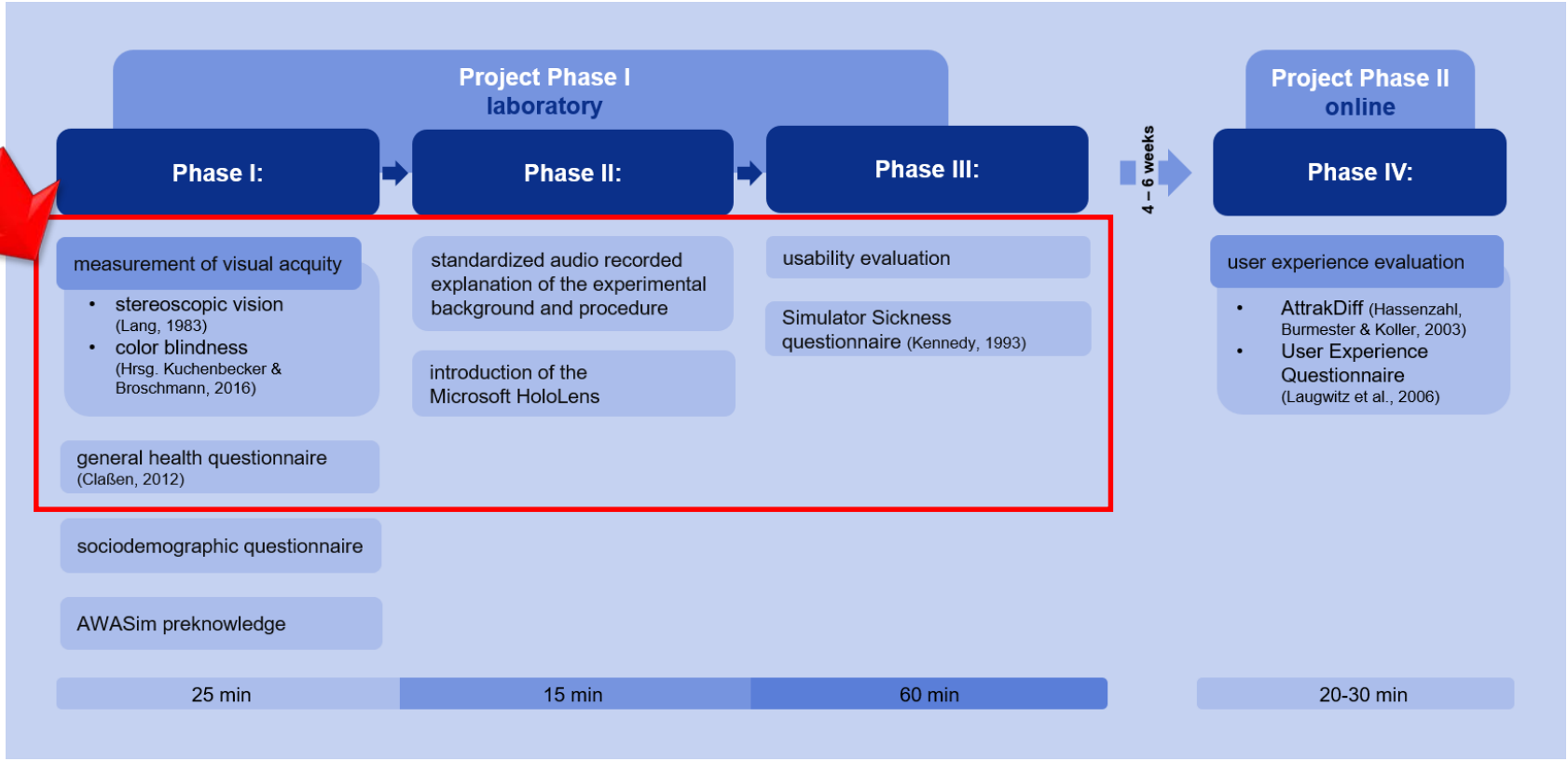




Where should the progess bars be displayed?

Teilen Sie hierzu bitte dem Versuchsleiter die Zahl der entsprechenden Darstellung mit.




Project Phase I
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Project Phase II
online
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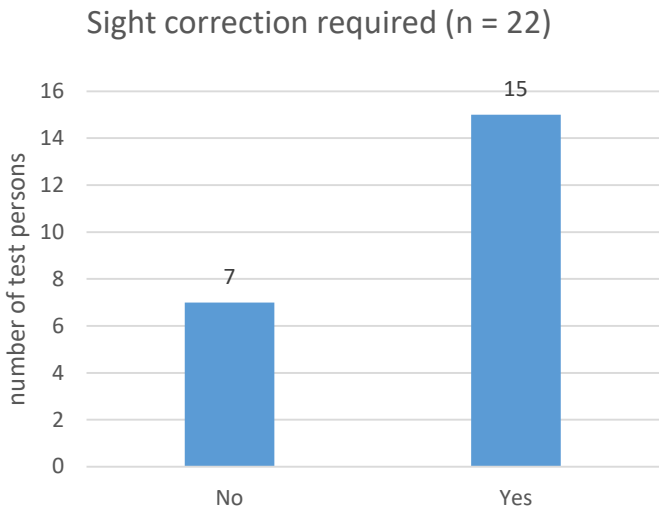
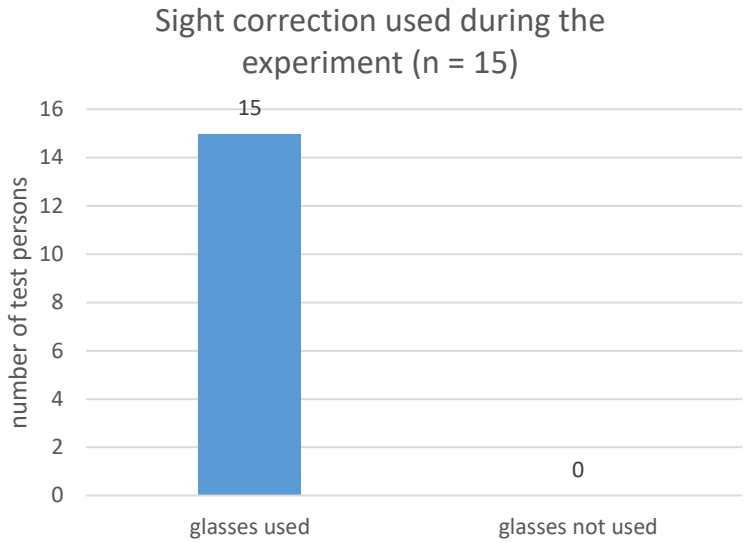
general health questionnaire (Claßen, 2012)
sociodemographic questionnaire
AWASim preknowledge
25 min
15 min
60 min
20-30 min

Sample Statistics

N = 22, Age 24.32 (min 19, max 51)
Male: 15
Femal: 3
Not specified: 4

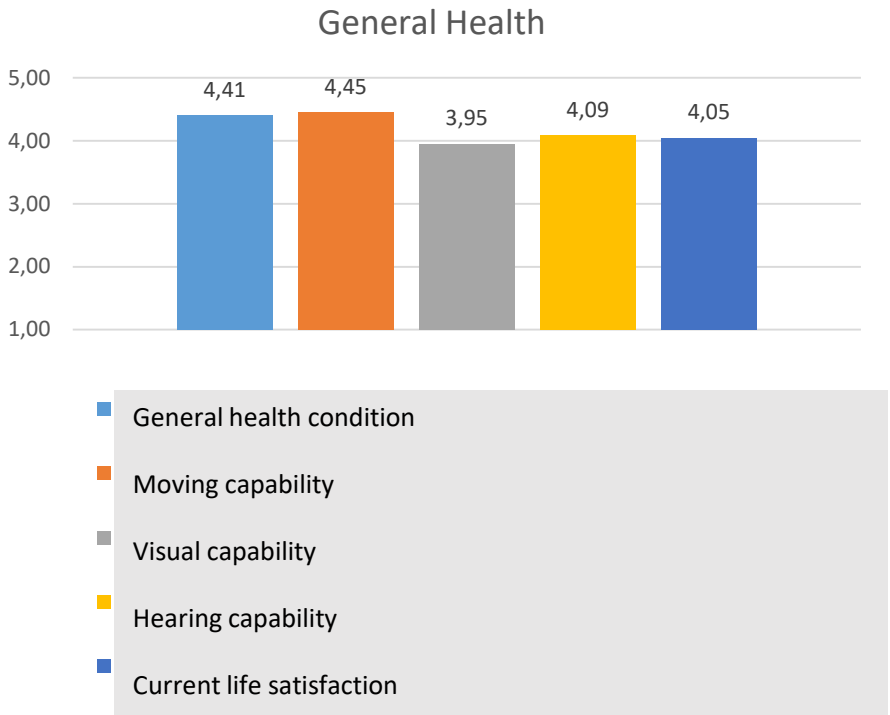


Measurement Visual Acquity



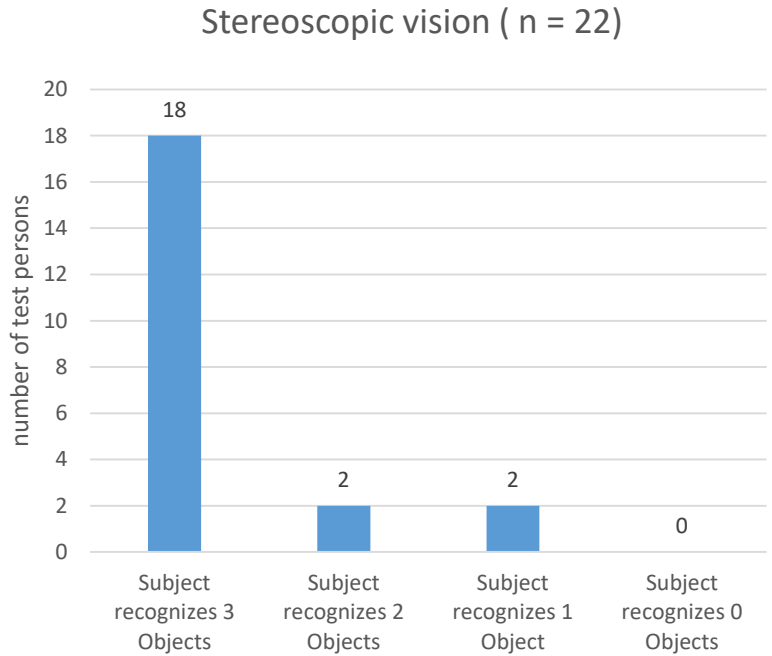
Pretest: Measurement General Health

(General Health Questionnaire; Claßen, 2012 based on Bullinger & Kirchberger, 1998)



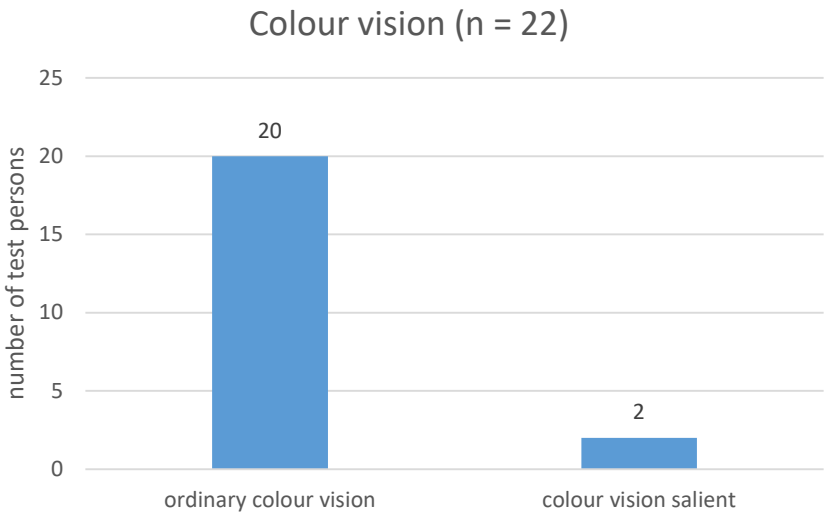
Measurement Visual Acquity

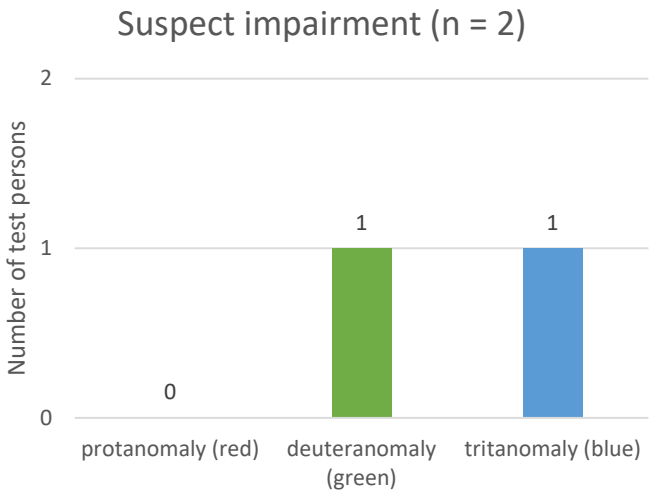
(Lang Stereotest; Lang, 1983)



Measurement Visual Acquity

(color blindness test; color charts by Kuchenbecker & Broschmann, 2006)





Usability Cluster Questionnaire (UCQ; Thomaschewski, 2019)

Scale	Example question	Cluster selection
Abstraction degree	"What is the best representation of a tank?"	Most chosen level (1 of 3), If chosen equally; choice by random number generator (RNG)
Object size	"The objects are very intrusive."	forced choice/ 3 options
Object distance	"The distance between the objects is just right."	forced choice /3 options
Object position (individual task/ IT)	"I would position the objects at this point."	forced choice / 5 options
Object position (team task/ TT)	"The position of the objects is helpful in operating the system."	forced choice / 5 options

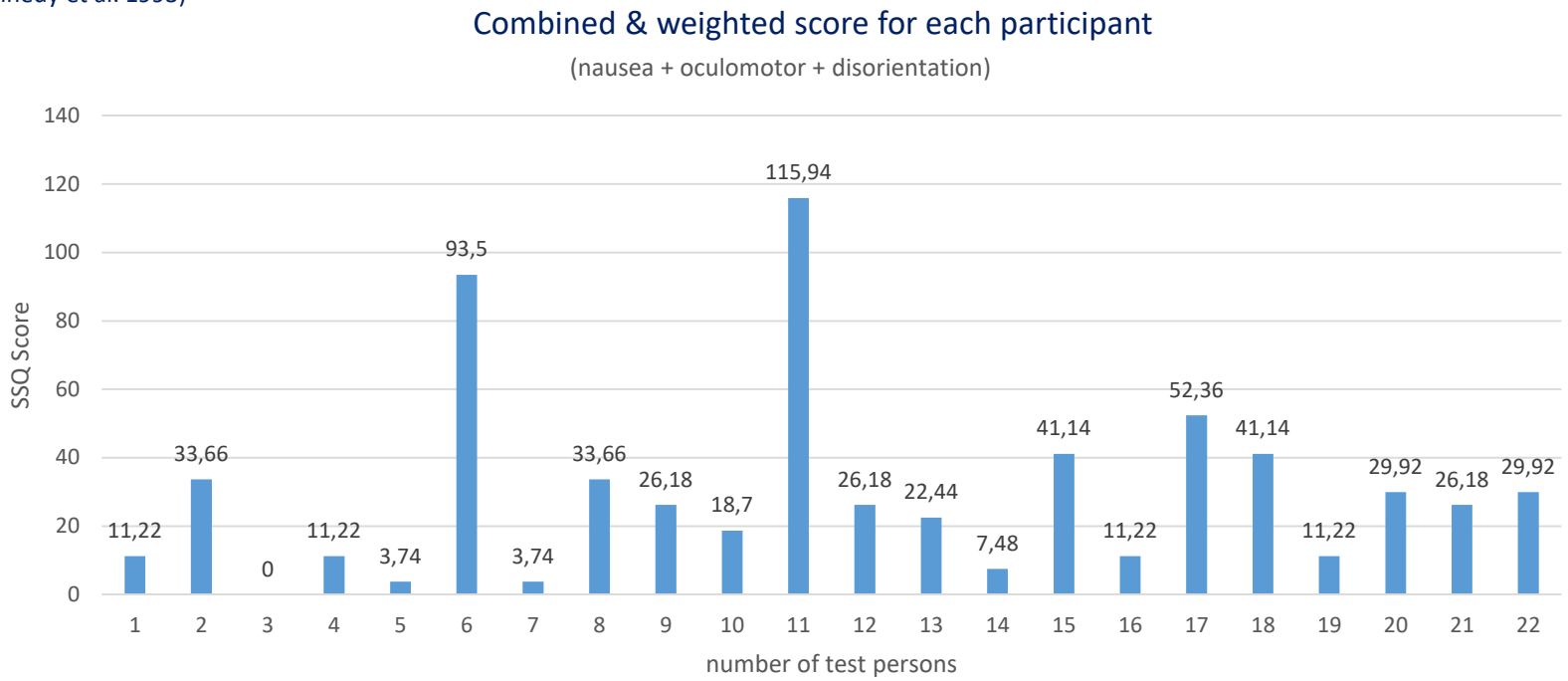
Usability Cluster Questionnaire (UCQ; Thomaschewski, 2019)

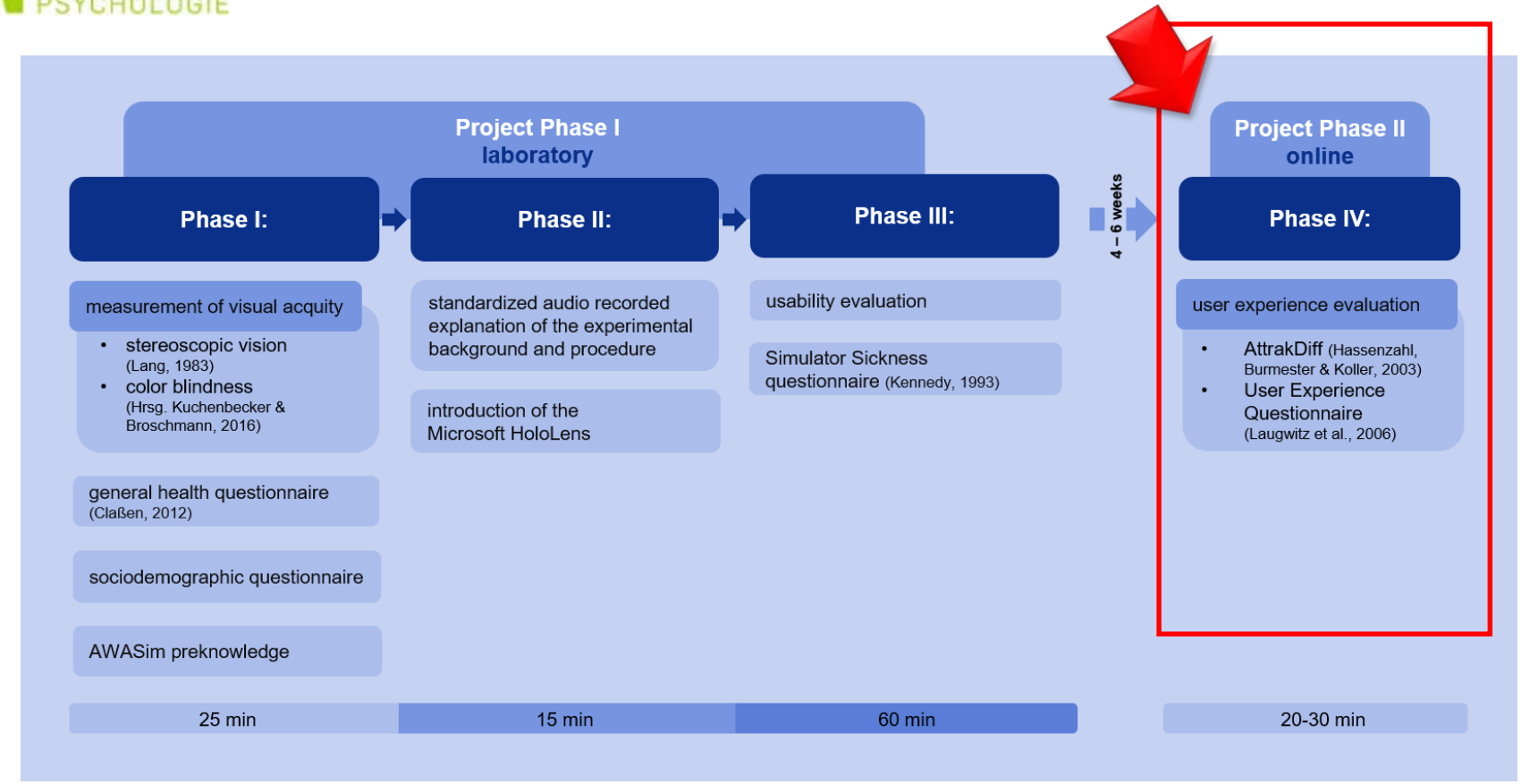
Scale	Example question	Cluster selection
Object-simulation distance (individual task/ IT)	"The objects are too far away from the AWASim surface."	forced choice between three options
Object-simulation distance (team task/ TT)	"I would position the objects at that distance."	forced choice between three options
Progress bar (individual task/ IT)	"The Progress Bar is disturbing at this point."	forced choice between four options
Progress bar (team task/ TT)	"I would position the Progress Bar at this point."	forced choice between four options
Dynamic indication	"The presentation conveys very well that I can now intervene in the Team Task."	forced choice between three options
Background	"The objects stand out strongly enough from their surroundings."	forced choice between three options

Simulator Sickness

(SSQ; Kennedy et al. 1993)

14 of 22 participants reported no change in physical condition (pre-post)

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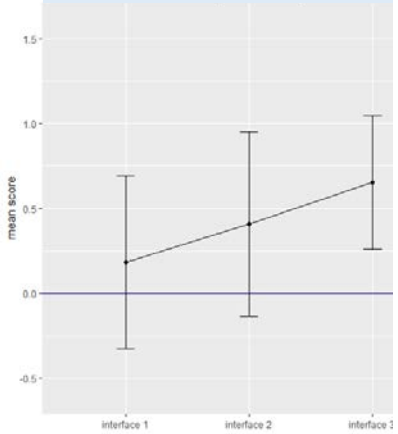
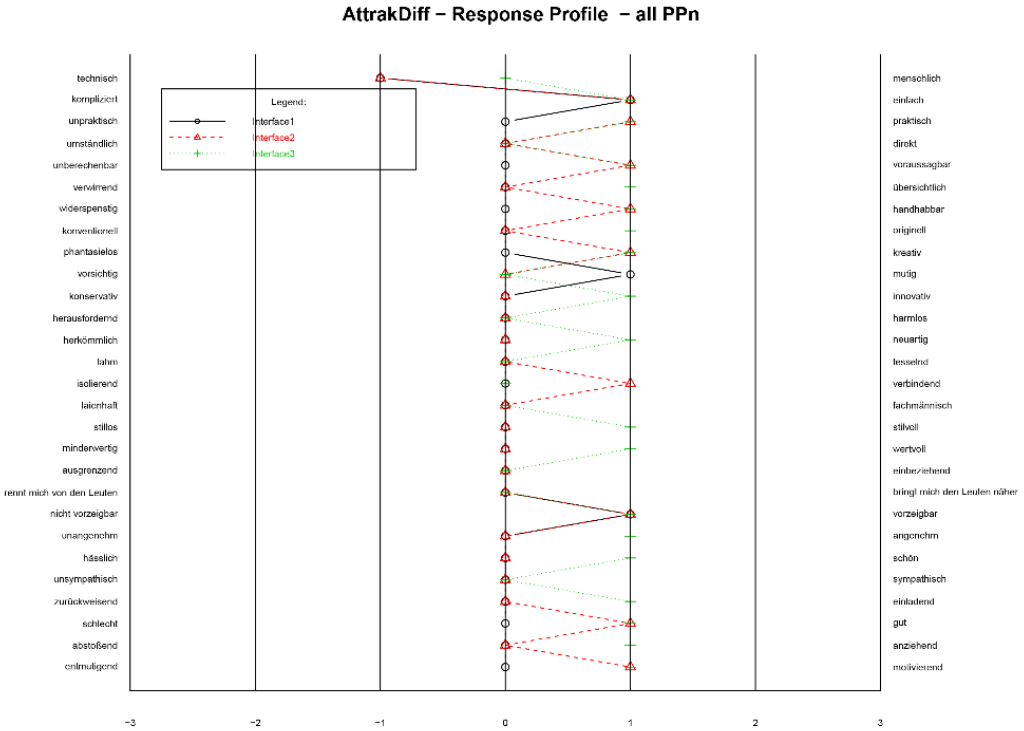
25 min
15 min
60 min
20-30 min

Usability – Pretest / online questionnaire

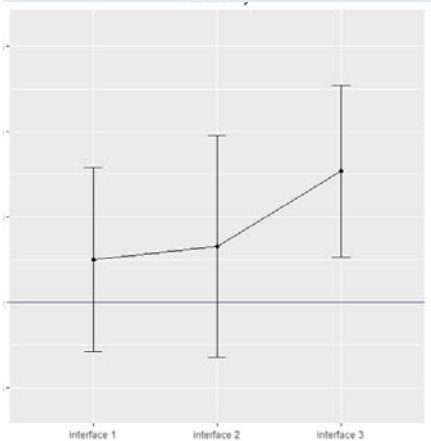
(AttrakDiff; Hassenzahl, Burmester & Koller, 2003)

Pragmatic Quality



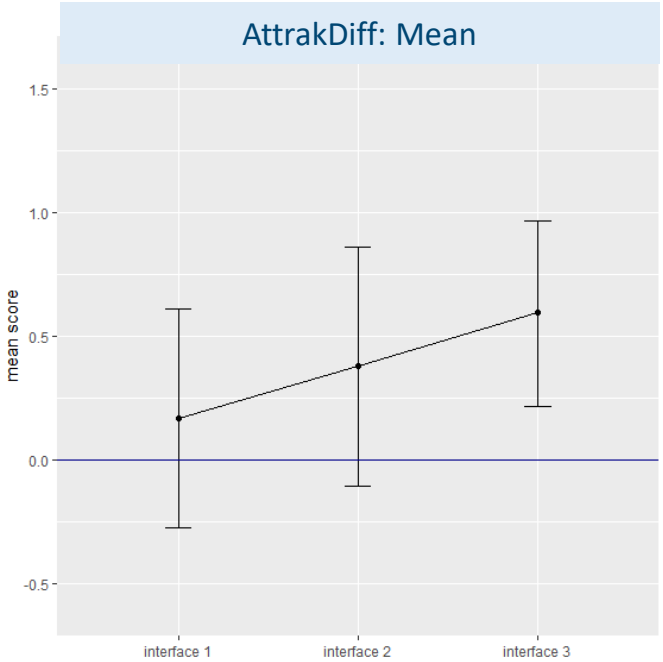


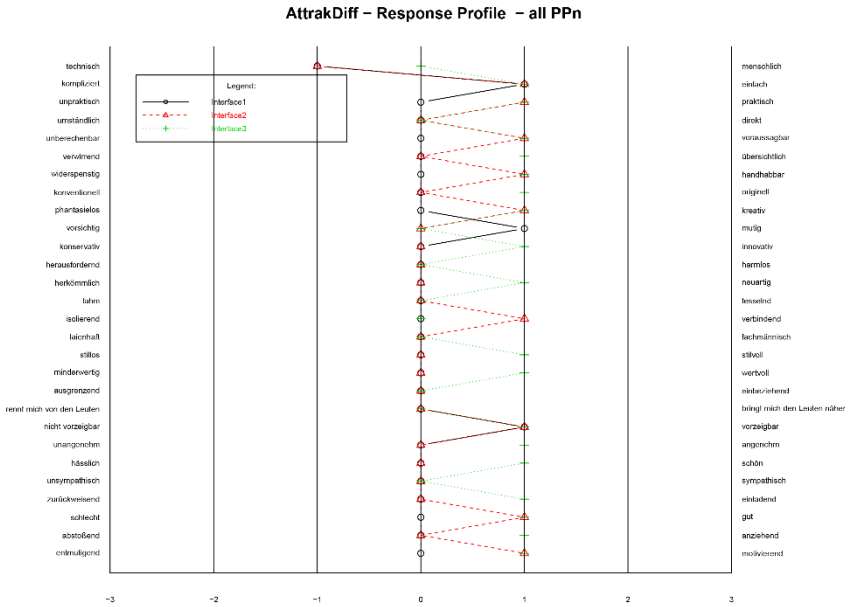
Attractiveness



Usability

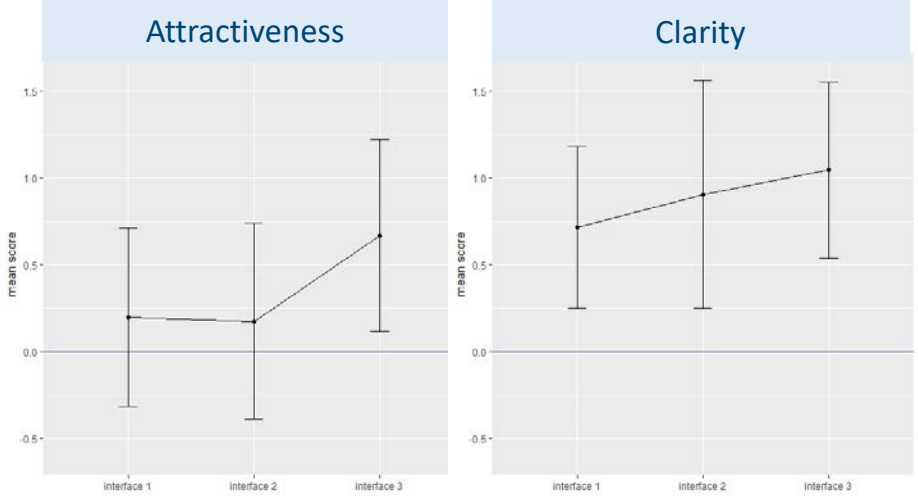
(AttrakDiff; Hassenzahl, Burmester & Koller, 2003)

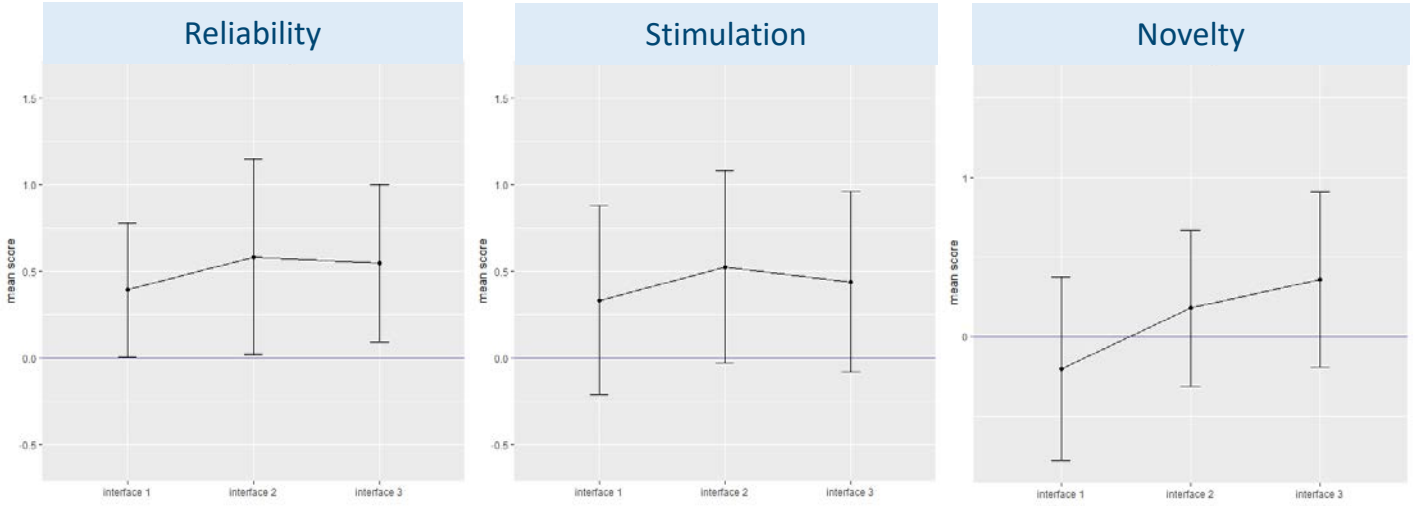




User Experience

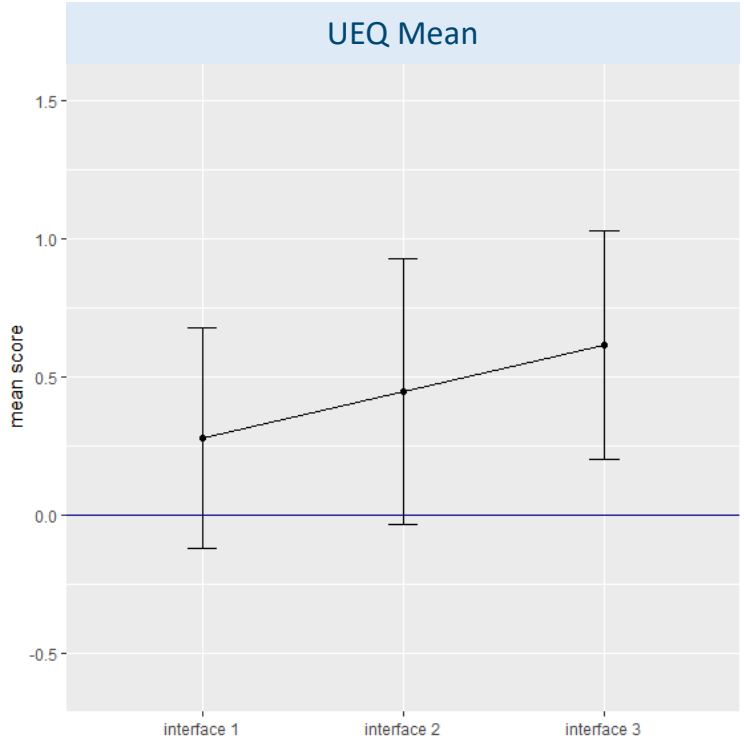
(User Experience Questionnaire; Laugwitz et al., 2006)

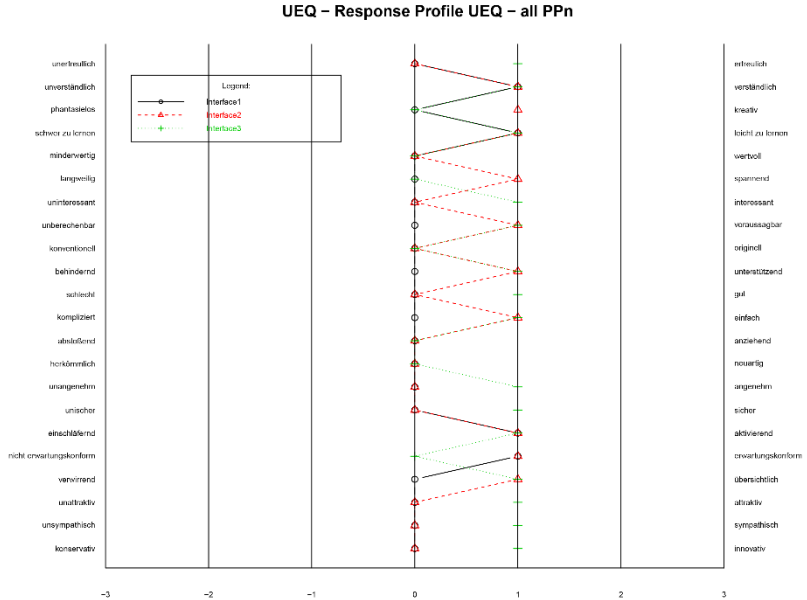




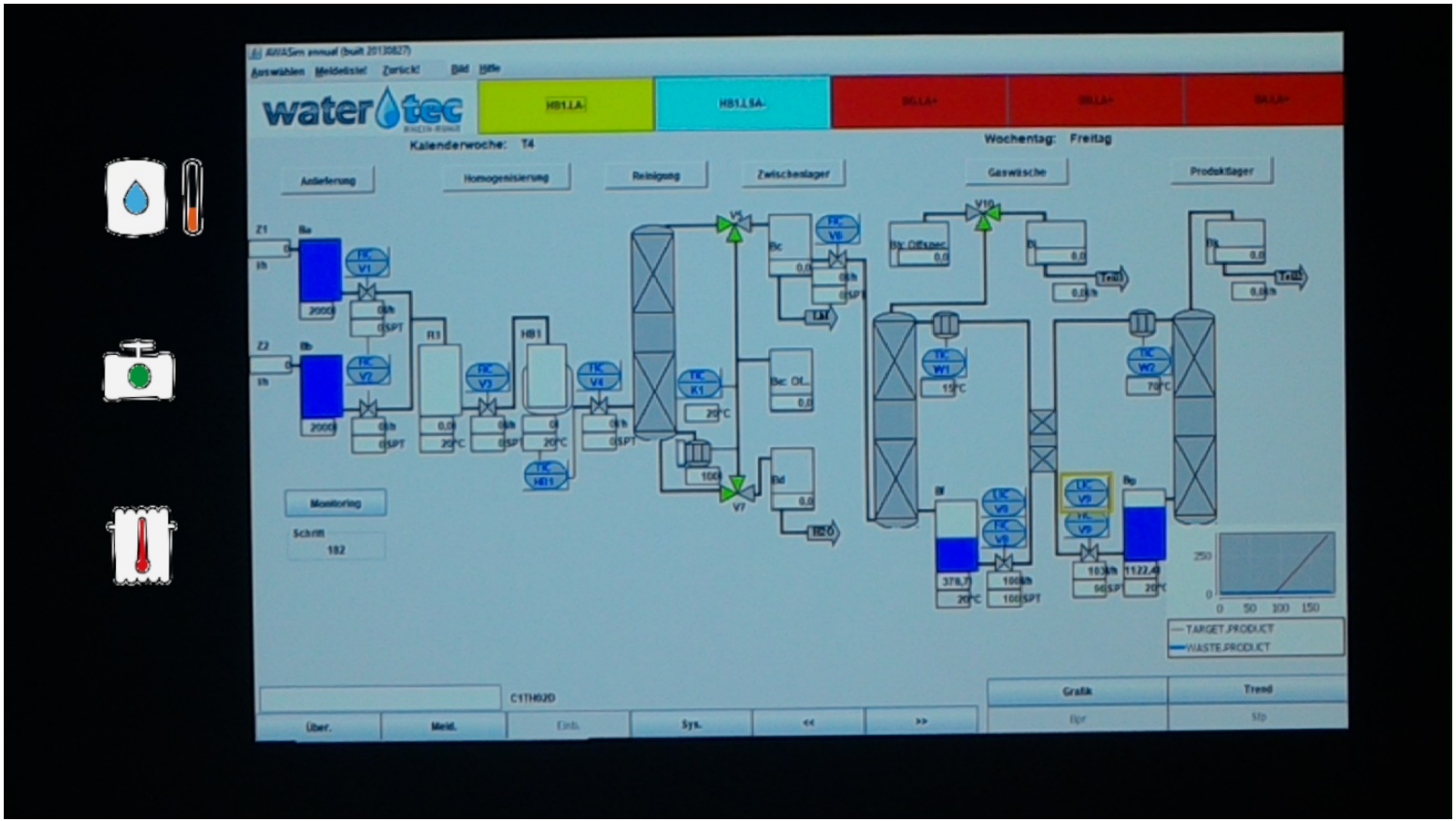
User Experience

(UEQ; Laugwitz et al., 2006)

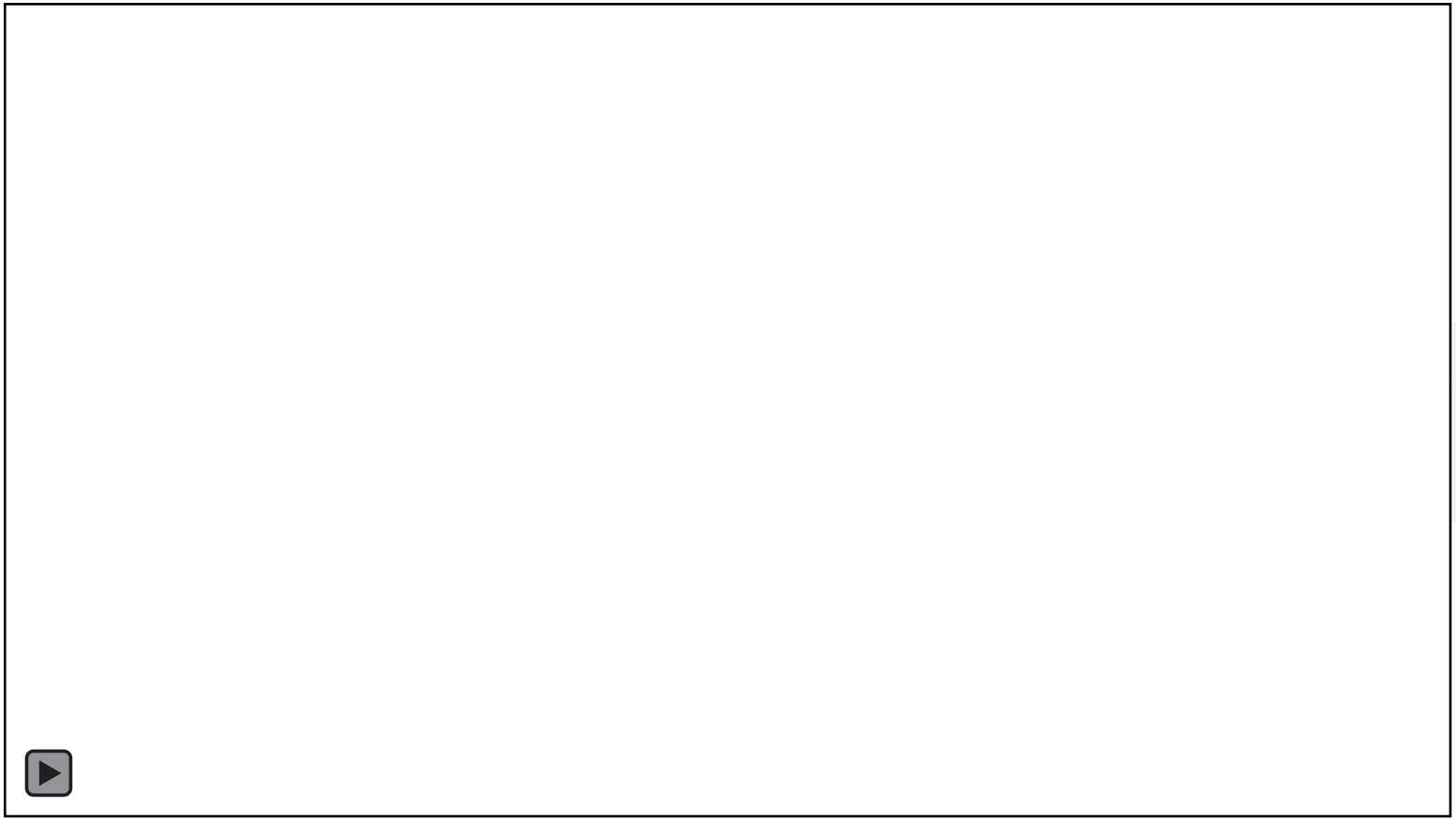




Final Interface IT/TT



Final Interface IT/TT (+ dynamic indication)



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Conclusion

- AR can help visualize dynamic effects (e.g. progress bars)
- AR can superimpose checklist items to reduce memory requirements
- AR can be used as a situative assistance for non-routine situations
- Ar can superimpose information from different screens
- AR can serve as a coordination assistance system for „being on the same page“
- **…if we aim for joint optimization of the social and the technical system**

Thank your for your attention

Prof. Dr. Annette Kluge
Lisa Thomaschewski (Leader Digital Realities)
Arnulf Schüffler
Greta Ontrup
Sebastian Brandhorst
Katharina Friedrichs
& Marina Klostermann

e-mail: annette.kluge@rub.de

http://www.aow.rub.de
http://www.spp1921.de
http://www.rub.de
ORCID: http://orcid.org/0000-0002-8123-0427
ResearchGate:
https://www.researchgate.net/profile/Annette_Kluge

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