5^{th} German Human Factors Summer School

Program

September 25^{th} - 26^{th}, 2023

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Part I

General Information

Welcome

We are happy to welcome you all to the Fifth German Human Factors Summer School 2023. The German Summer School for Human Factors is the successor of the Berlin Summer School of Human Factors which was initiated and organized from 2014-2018 by the Department of Psychology and Ergonomics, TU Berlin. The Summer School is an annual postgraduate event that is supported by the Section of Engineering Psychology of the German Psychological Society (DGPs).

The intention is to provide an interactive platform that promotes the transfer and communication of interdisciplinary skills relevant to Human Factors research. Successful postgraduate applicants (Ph.D., M.Sc., and candidates) have the opportunity to present their research interests and/or current projects for critical discussion. Prominent researchers are invited to teach advanced methods and communicate state-of-the-art research from their laboratories.

The 5th German Summer School for Human Factors is hosted by Chemnitz University of Technology from September 25th to 26th. We are looking forward to inspiring talks and discussions.

Target audience

The target audience is Ph.D. students working in Human Factors, irrespective of whether they have just started or almost finished their Ph.D. The objective of the Summer School of Human Factors is to offer a space for Ph.D. students to connect and help each other with the empirical parts and handling of other issues concerning the Ph.D. Also, the summer school will be attended by invited senior researchers and guests, further facilitating the discussions.

Venue

The summer school will take place at Altes Heizhaus (Chemnitz University of Technology). The Venue can easily be reached by public transport or car.

Accommodation

Check the connectivity between the venue and your preferred accommodation. We provide some suggestions for accommodation on our website.

Information for presenters

Each talk will be scheduled for 15 or 30 minutes (depending on whether a single study or a PhD overview is presented):

- During the talk, the contributor has the opportunity to initialize and lead a discussion about his/her current project. On this account, contributors can give a short introduction to their current project and use the rest of the time for an intense discussion with the audience.

Questions?

If you want to get in touch with the organizers to discuss some ideas or upcoming questions, please get in touch via email:

- lewis.chuang@phil.tu-chemnitz.de

Program

Monday, 25.09.2023

08:30 – 09:00	Registration
09:00 – 10:00	**Welcome and Serious Play**
	Lewis L. Chuang
10:00 – 10:45	**Talk: Humans and Technology**
	Lewis L. Chuang
10:45 – 11:30	**Posters and Coffee**
	Participants
11:30 – 12:45	**Talks: Research on Humans and Technology**
	Participants, Group A
11:30 – 11:45	Eva Gößwein
11:45 – 12:15	Marie Klosterkamp
12:15 – 12:45	Ilka Hein
	Participants, Group B
11:30 – 11:45	Maximilian Kullmann
11:45 – 12:15	Jochen Miksch
12:15 – 12:45	Sebastian Pütz
12:45 – 13:30	Lunch break
13:30 – 14:15	**Talk: Interfaces for Sustainable Eco-Driving Behvior**
	Thomas Franke (Uni Lübeck)

14:15 – 15:15	**Talks: Research on Humans and Technology**
	Participants, Group A
14:15 – 14:45	Angelina Krupp
14:45 – 15:00	Lin Lin
15:00 – 15:15	Josephine Halama
	Participants, Group B
14:15 – 14:45	Mourad Zoubir
14:45 – 15:00	Markus Gödker
15:00 – 15:15	Marthe Gruner
15:15 – 16:00	**Posters and Coffee**
	Participants
16:00 – 17:30	**Forum: Life after PhD in Academia/Industry** Martin Baumann (Uni Ulm) Franziska Schmalfuß (IAV GmbH) Michael Oehl (DLR Braunschweig) Lewis Chuang (TU Chemnitz)
17:30 – 18:30	**Q&A Session: Applications for the Visually Impaired**
	Kai Weser
19:00 – 21:00	**Social Event: Dinner @Living Labs** **Conversation Topic: What is "Good"?**

Tuesday, 26.09.2023

09:00 – 10:00	**Keynote Talk: Accessibility, Assistive Technology, and Human-Computer Interaction** Prof. Gerhard Weber (TU Dresden)
10:00 – 10:45	**Forum: What are "Good" Technologies?** *Participants*
10:45 – 11:15	**Posters and Coffee** *Participants*
11:15 – 12:15	**Keynote Talk: AR and DR for Good?**
12:15 – 13:00	Lunch break
13:00 – 17:00	**Practical: Crash Course on Unity Programming** Alessandro Forgiarini (Uni Udine, IT) Mateu Sbert (Uni Girona, ES)
17:00 – 18:00	**Talk: Future of XR** Marius Klug (BTU Cottbus-Senftenberg)

Part II

Abstracts

Transparent Passenger Communication during Minimal Risk Maneuvers in Highly Automated Vehicles (L4)

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Highly automated vehicles (HAVs, SAE 4) promise efficient, safe and inclusive transportation at an affordable price. Advanced concepts were developed without any fallback driver inside the vehicle. Though this is necessary to improve efficiency and affordability, it creates an unknown situation for future passengers. They no longer have a human driver present to reassure in uncertain situations, for example in minimal risk maneuvers (MRMs). MRMs are triggered when the vehicle automation encounters situations it cannot handle. In these situations, the HAV needs further assistance, which can be realized by the use of remote operation (RO). RO incorporates a human operator, who supports the HAV remotely (e.g. from distance) during MRMs and gives instructions to resolve these unknown situations. The combination of new situations, and the lack of a driver who could interact with passengers results in the need for new informational concepts inside the HAVs. The design and information richness of these concepts most likely influence passenger's experience and acceptance of HAVs. Additionally, a basic and more intuitive understanding of the automation and its functionalities might be beneficial for passengers' experience. Previous studies indicate that providing transparency by design might improve passengers understanding of the automation systems and increase trust. In theory, transparency improves when information about

the actions and reasoning of a systems behavior is presented alongside its behavior. Yet, the specific design of informational interfaces in order to be transparent about the reasoning, especially in MRMs, is still unclear. Therefore, we investigated the impact of promising factors in an online study. Participants of the study evaluated different interfaces in multiple scenarios, where the HAV has to perform an MRM. The presented interfaces varied in displayed information richness to systematically manipulate transparency in the vehicle automation. The information varied concerning the vehicleÂ´s behavior and reasoning. The design with the highest information richness also added expected consequences, like delay time, to the interface. The results of this study indicate that improvements of passenger's understanding in MRMs are linked with increased transparency of provided information. Understanding regarding those MRMs scored significantly higher in the information richest design compared to the design without MRM specific information.

Keywords: Human-Computer Interaction, Highly Automated Vehicles (HAVs, SAE L4), Remote Operation, Explainable AI (XAI)

Exploring the Measurement of Sense of Agency in Human-AI Collaborative Tasks

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Recent advances in AI-agents, such as the development of Large Language Models (LLMs), open new opportunities for human-AI agent collaboration. In this realm, one challenge is to understand how humans feel in collaborative tasks, which has implications for task-productivity as well as human understanding and trust towards an AI. Therefore, we aim to augment intelligent systems in a way that the abilities and needs of the human team partner are anticipated and integrated in this process. Humans require a feeling of system control to make decisions for action (Jameson & Schwarzkopf, 2002). A relevant psychological concept for this is sense of agency (SoA). The term "sense of agency" stands for many phenomena that - not exhaustively - describe task perception and action considering system feedback and world knowledge (Pacherie, 2007). It is used interdisciplinary, ranging from philosophy, psychology, neuroscience, robotics, and cognitive science and faces conceptual and methodological challenges.

SoA encompasses the experiences of, e.g., intentional causation, the sense of initiation, and the sense of control (Pacherie, 2007). It has been investigated in various basic research contexts and some applied contexts, e.g. system feedback (e.g., Desantis et al., 2011; Farrer et al., 2008; Sato and Yasuda, 2005), task automation (e.g., Berberian et al., 2012), human-agent collaboration (e.g., Obhi and Hall, 2011; Wohlschläger et al., 2003) and human-embodied agent collaboration (e.g., Murphy et al., 2010. Research is needed to validate methods to assess SoA in human-AI collaboration, specifically in ill-defined problem-solving.

There are several ways of investigating SoA. On one hand, we can look at the subjective experience and on the other hand at objective measures such as task engagement. Explicit measures like the Sense of Agency Scale (SoAS) (Tapal et al., 2017) need to be validated for the task at hand. Implicit measures for SoA include intentional binding (e.g. Haggard et al., 2002) and sensory attenuation (e.g. Blakemore et al., 1998), which, especially intentional binding, have been looked at in various settings (Aarts & van den Bos, 2011; Moore et al., 2009; Wohlschläger et al., 2003).
One intuitive understanding of the relationship between sense of control and degree of automation is the more automated an action is, the less control in the task is felt. Whereas in another understanding, the more automated an action is, the human has more available capacity to compensate for other subtasks, leading to the perception that actions are more controlled (Berberian et al., 2012). The question arises how compartments of SoA behave in human-AI collaborative task measures for understanding sense of control.
We aim to develop AI-agents to fit the needs and abilities of the respective human partners. Thus, it is necessary to simultaneously look at antecedents of collaborative tasks (e.g. human-, task-, or AI characteristics), how these influence the process in collaborative tasks which then affect the consequences of it such as SoA, task engagement and user evaluation (Janssen & Kirschner, 2020).

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Paving the way for Ecodriving Studies in an Electric Vehicle Driving Simulator – The Ecodriving Test Park

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Energy-efficient driving, commonly referred to as ecodriving, plays a crucial role both at the societal and individual level in the context of electric mobility. However, drivers often face challenges in understanding the factors that influence energy efficiency and how to modify their own behavior to achieve lower average energy consumption (Barkenbus, 2010). Various means such as human-computer interfaces, training programs, and automated functions can assist drivers in achieving energy-efficient driving (Sanguinetti et al., 2020). Nevertheless, to assess the effectiveness of these driving support systems, it is necessary to conduct (besides field studies or test drives) controlled experiments in observable environments, such as driving simulators. The objective of the present research is to conceptualize, develop, and analyze a series of driving simulation test cases specifically tailored for energy-efficient driving experiments, referred to as an "ecodriving test park".

Driving simulation experiments offer several advantages, including the ability to create controlled environments and tasks to understand influencing factors on driving behavior. However, in many ecodriving simulator experiments, the task environment is described only coarsely (e.g., Almallah et al., 2021; Staubach et al., 2014). Typically, the test routes are merely classified as urban or rural, and the intended maneuvers are mentioned. This approach poses a problem if we lack a comprehensive prior understanding of how these characteristics influence the driver's experience and behavior of interest. This limits our ability to interpret the interaction between the interventions of interest and the driving situation. For example, one major situational factor that is assumed to influence the driving performance in general (Paxion et al., 2014) is the complexity of the situation. In the context of ecodriving, (Franke et al., 2016) have also found that environmental complexity influences the ecodriving strategy selection. In order to accurately observe and describe the driver-vehicle interaction, we must (1) establish a taxonomy to describe driving situations based on situation elements such as paths, signs, traffic, and weather (see for example, Geyer et al., 2014; Scholtes et al., 2021), (2) comprehend the consequences of these elements on driver behavior and experience, and subsequently (3) investigate the primary and interaction effects of interventions in specific situations on the driver. A similar approach was undertaken by (Fastenmeier & Gstalter, 2007) in their study on safe driving, where they analyzed road traffic situations and derived psychological driver requirements.

We pursue this approach by developing a set of driving scenes for use in driving simulator experiments with the following criteria: Most central, the driving scenes must incorporate ecodriving maneuvers, ensuring that inefficient and efficient driving yield measurable differences in energy consumption. We call this attribute of driving situations *energy relevance*. Furthermore, they must operationalize driving situation characteristics that are relevant to specific research questions (in our case the level of complexity involved). Additionally, classical test theoretical considerations, including objectivity, reliability, validity, fairness, economy, and external validity, need to be considered. For this, the individual test cases need to be comparable, clearly defined, independent of their running order, etc.

Building on the discussion of (Rommerskirchen et al., 2014), we assume that the complexity of a driving scene encompasses multiple facets, including visual information, route requirements for lateral and longitudinal control, concurrent tasks, event uncertainty, time constraints, and more. However, conducting experiments in a controlled setting poses a challenge when attempting to vary the complexity of the situation. The variation of complexity-related elements such as speed limits, curves, and traffic events directly impact driving behavior, leading to incomparable driving data from different scenes. To address this issue, (Rommerskirchen et al., 2014) chose to modify only those elements that do not directly influence driving behavior, such as other road users, lighting conditions, and road construction that does not directly influence driving behavior. Nonetheless, this approach results in the exclusion of essential complexity-related aspects, especially the complexity of traffic routing leading to higher lateral and longitudinal control demands. As a result, we have opted to include both visual complexity and control complexity as independent factors in our test park.

We operationalized visual complexity as the quantity of visual information unrelated to the driving task (like in Rommerskirchen et al., 2014). Control complexity was defined as the extent of lateral and longitudinal control requirements in relation to the available time and the certainty of their occurrence. Energy relevance on the other hand, was defined as the disparity between the most and least energy-efficient – but still realistic – driving styles. The final test park should encompass a broad range of visual and control complexity while incorporating high energy relevance. To achieve this, the AMORi project team created verbal descriptions of various scenarios. We selected appropriate scenes and categorized them based on our defined characteristics. Subsequently, the driving simulator team and a group of students built the environment and roads within the simulator, following the verbal descriptions in an iterative design process. For example, the scene *simple constant drive* has been verbally described as “constant driving 50 km/h in town with slightly undulating terrain, no curves, free driving“ and is planned to incorporate low control complexity.

Simultaneously, we established a set of instructions and rules that the drivers must follow to achieve a realistic balance of driving goals and to improve relative behavioral validity (Hock et al., 2018). In essence, these rules encompass the following aspects: (1) minimizing energy consumption per distance covered, (2) reaching the goal within a specified time limit that is what a slow but socially acceptable driver would need to reach the goal (in our initial test study 80% of the speed limit), and (3) adhering to traffic regulations and avoiding collisions. It is important to note that participants were not provided any additional financial incentives for accomplishing these objectives, nor were they subject to penalties for noncompliance, as external factors such as participants' financial circumstances could unduly influence their behavior (cf., Hock et al., 2018).

To evaluate the ecodriving test park, an initial test study ($N = 25$) was conducted to gather empirical data on the variation in energy consumption and to assess the success of the intended operationalization (manipulation check). Based on these results, we discuss the concept of the test park and propose potential modifications. Furthermore, we examine the usefulness of the test park in relation to the research questions of our ongoing AMORi project and its broader applicability in general.

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On the Front Lines of AI: A Systematic Review of AI-Based Decision Support in Emergency Management

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In emergency management, decision-making is often characterized by uncertainty, time constraints, and a dynamic environment (G. Klein, 2008; Osman, 2010). Uncertainty arises primarily due to insufficient verbal information by third parties (i.e., observers in the field; McGuirl et al., 2009). In high-risk situations, this may lead to a heavy reliance on biases and a high persistence of unsuccessful strategies, which increases the risk of erroneous decisions (Osman, 2010). With increasing integration of technological advances in the field (Simpson & Hancock, 2009), visual context information on critical incidents from unmanned aerial vehicles (UAVs) and instant analysis of this information (e.g., by Computer Vision) is a promising approach to reduce uncertainty and support operations (Brennan et al., 2019; Khan & Neustaedter, 2019). Considering these progressions, a comprehensive understanding of the impact of visual context information acquisition and analysis on decision-making processes in emergency management are critical.

This systematic review aims to highlight the current state of human factors research on the support of emergency management by visual contextual information, focusing on the impact on human decision-making processes. The review will cover various aspects of the impact, including overall effects, reported benefits, potential limitations, future research implications, and the feasibility of integrating this technology into conventional systems and processes.

To address the research objective, the review is structured according to the PRISMA 2020 guideline (Page et al., 2021). A comprehensive search in relevant databases such as PubMed, IEEE Xplore, ScienceDirect, ACM, and Web of Science is conducted. Only empirical studies that specifically examine the effects of support in emergency management by visual context information on any aspect of decision-making processes is included.

Based on the thematic analysis approach (Braun & Clarke, 2006), the extracted data will be synthesized and analyzed to highlight key themes, research methodologies used, and investigated domains. Based on the resulting data, a meta-analysis of relevant research is sought. Themes anticipated to emerge include the impact of visual context information on decision performance, situation awareness, workload, and subjective assessments of the decision-making process.

This review potentially provides an opportunity to establish an evidence-based framework for future human factors research in emergency management and to inform practical advances in the development of technologies and emergency management operations.

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What Difference Does It Make? The Impact of visual context information on Decision-Making in Emergency Management

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Objective: The objective of this pilot study is to investigate the impact of the type of information source (visual context information vs. verbal information) on the decision makers' judgment of in emergency situations with varying levels of complexity. In particular, the influence of visual context information on performance in judgment, situation awareness, and perceived uncertainty of judgment will be examined.

Background: In the face of increasingly frequent and devastating wildfires (World Meteorological Organization, 2023), emergency management is faced with major challenge now and even more in the future. However, emergency managements' decisions still typically rely on verbal information of from laypeople observing the incident, a source that often varies widely in both quantity and quality (Terrell, 2006). This verbal information is highly subjective and frequently incomplete, unreliable and/or ambiguous (G. Klein, 2008; Lipshitz et al., 2001), leading to decisions being made under high uncertainty (cf. e.g., Osman, 2010).

The increasing presence of unmanned aerial vehicles (UAVs) in public services has opened new opportunities to reduce dependence on verbal information and enable decision making through objective visual contextual information (see, e.g., Alon et al., 2021; Baumgarten et al., 2022; Brennan et al., 2019). One goal of UAV integration in emergency management is to constantly

monitor potential fire prone areas. In case of detection, they can then alert emergency management directly and at an early stage, preventing extensive harm. However, there is still a lack of understanding how visual contextual information impacts the judgement in emergency situations.

Method: In this study, a mixed experimental design is employed with emergency dispatchers as participants. Participants are presented with either verbal context information or visual context information (between-subject) in hypothetical emergency scenarios with varying levels of complexity (within-subject), in a counterbalanced order to avoid order effects. After each scenario, participants' performance in judgement of the situation (accuracy and seed), situation awareness and perceived uncertainty are measured. Hypothetical emergency scenarios are developed in close collaboration with emergency management experts, focusing on current critical scenarios that challenge decision-making in safety-critical situations.

Results (Hypothesis):
HT 1: Participants presented with visual contextual information show higher accuracy in judging emergency situations and exhibit higher situational awareness and lower levels of perceived uncertainty than participants presented with verbal contextual information.

HT 2: As the complexity of hypothetical emergency scenarios increases, participants' judgment accuracy and situation awareness will decrease, and perceived uncertainty will increase.

HT 3: The source of contextual information (verbal vs. visual) will interact with the complexity of the scenario, such that the difference in judgment accuracy, situation awareness and perceived uncertainty between the two conditions will be more pronounced in more complex scenarios.

Conclusion: As this study is a pilot study, supported hypotheses would provide preliminary evidence for further investigation. Indications are that the integration of visual context information can improve decision making, i.e., judgment accuracy, situational awareness, and subjective judgment confidence, in emergency dispatchers compared to verbal contextual information. A more comprehensive study, however, will be necessary to confirm these results, explore additional factors that may influence decision-making of dispatchers in uncertain emergency situations.

Application/Implications: Should the hypotheses be confirmed, this would suggest that visual context information can improve the decision-making process in safety-critical situations. Initial insights could serve as a foundation for more substantial and extensive research to further validate and investigate the potential impact of integrating UAV technology in emergency management.

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Designing for the Greater Good: Application of Value Sensitive Design in Automated Driving

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Objective: The aim of the project is to create a framework to explain vulnerable road users behavior during their interaction with automated vehicles. The framework is derived from related work and will be improved iteratively through empirical investigations. In order to address the welfare of individuals and society – the greater good – the work incorporates theoretical foundations and methods of value sensitive design (VSD, e.g., Friedman, 1996).

Background: The theories and methods of VSD can be applied to conceive, design, and use technology in a moral and ethical manner, promising improved interactions with technologies and a better future (Friedman & Hendry, 2019). When applied to the context of automated driving and the interaction with vulnerable road users, the goal is to enable a safe and smooth interaction that takes into account the values and expectations of different stakeholders. The identification of stakeholders and their values is of particular importance in Value Sensitive Design. Stakeholders are individuals or groups who will be significantly affected by the technology, either today or in the future (Friedman & Hendry, 2019).

Method: One method for identifying stakeholders and their relevant values is through a stakeholder analysis. In the project, this was carried out with two expert focus groups, with six participants in each group ($N = 12$). First, the human factors experts identified the relevant stakeholders in interaction scenarios of vulnerable road users (pedestrians and cyclists) with automated vehicles. Subsequently, the experts defined the most important stakeholders for interaction situations, and benefits and harms are gathered. Following that, values were derived based on the benefits and harms. The investigations concluded with an assessment of the importance of stakeholder values and the identification of value tensions.

Results: A content analysis was conducted using MAXQDA. The experts found 14 different groups of stakeholders. Pedestrians, cyclists, none vulnerable road users (like cars), manufacturers, passengers, legislators and the control center (teleoperator) were identified as the most important stakeholders in the given interaction situation. However, the experts found it challenging to determine whether individual stakeholders, such as passengers and manufacturers, were direct or indirect stakeholders in the interaction situation. For each stakeholder, numerous values were identified, including human welfare, reliability, privacy, trust, courtesy, freedom, self-efficacy, justice, and efficiency. In the analysis, approximately half of these values could be linked to the typical values of the VSD approach (Friedman et al., 2002).

Conclusion: The results of the expert focus groups and findings from the related work serve as a starting point for value-based development of a framework for the interaction of vulnerable road users and automated vehicles.

Application/Implications: The research aims to contribute to the development of automated vehicles and the interaction process with vulnerable road users in a value-based, safe and smooth way. In general, the VSD approach is well-suited for identifying relevant values and can be considered an approach to promote the greater good.

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From Black Box Systems to Transparent Technologies – Improving the User Experience Through Explanatory Cues

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Technologies are becoming increasingly powerful and smarter, but at the same time less transparent to their users (e.g., Diefenbach et al., 2022; Holzinger, 2018). The users might not, for example, understand how the technology works and arrives at its outputs. As a result, this can negatively affect users' experience, reduce their trust in the technology, and condition a lower intention to use (e.g., Samek and Müller, 2019; Shin et al., 2020; Silva et al., 2022). In addition, legal requirements for designing transparent technologies are increasingly being introduced (e.g., General Data Protection Regulation, discussion about a European AI act). Using the term Explainable AI, previous investigations mostly focused on the technical implementation of transparent systems and neglected the user experience (e.g., Nunes and Jannach, 2017; Samek and Müller, 2019). Moreover, research on transparency cues was often limited to single application contexts (e.g., recommender systems), exploratory in nature, and not theory-driven (e.g., Liao et al., 2020; Liao and Varshney, 2022; Miller et al., 2017). In summary, no scientific consensus exists on what level of transparency technologies should provide, how transparency cues should be designed, and to what extent this depends on individual differences or the context (e.g., Diefenbach et al., 2022; Nunes and Jannach, 2017).

In my PhD project, I aim to address the above-mentioned shortcomings of the current research on technology transparency. In contrast to the fragmented and not very user-oriented approach practiced so far, I intend to investigate technology transparency more comprehensively and oriented towards the design process of technologies (e.g., Laato et al., 2022). Therefore, different AI systems, contexts of use, and stakeholders will first be considered to assess the need for transparency. On this basis, it will then be examined which aspects should be made transparent (what aspects) and subsequently how these should be presented (how aspects; Hein et al., 2023). Thereby, the project will provide theoretical implications as well as practical contributions by deriving recommendations for the design of transparent technologies.

At the Summer School for Human Factors, I would like to present my PhD project in a talk, discuss it with other participants, and thereby take suggestions for improving and further developing my research. The focus will be on the selected topic of technology transparency, the research questions to be investigated, possible methods and the tentative timeline.

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Enabling automated vehicles for predictable and intuitive interactions with surrounding manual road users in shared spaces

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In recent years, there has been an increase of automated driving functions enabling for safer, more efficient and comfortable road traffic. In automated vehicles (AVs; SAE level 3 or higher), interactions between involved traffic participants will change since the driver (i.e., the person on the former driver's seat, subsequently still referred as 'driver') will be allowed to engage in other tasks than driving or might be even absent. Therefore, the commonly established communication dyad in manual driving, including the driver and surrounding road users around the vehicle will change to a communication triad in AVs, comprising the driver, surrounding road users and the vehicle automation. In AVs, the vehicle automation itself might need to interact with surrounding road users to coordinate encounters. This interaction transformation leads to the objective how intuitive and predictable encounters between AVs and surrounding manual road users might be prospectively achieved. Thus, communication signals provided by AVs need to be highly intelligible, transparent and distinct. Since accepted gaps (gap acceptance; GA) in traffic flow are frequently applied for coordinating encounters in manual road traffic, the current PhD thesis investigated GA as a specific parameter of implicit communication (i.e., as a parameter of a dynamic Human-Machine Interface in AVs; dHMI). Moreover, additional communication signals in AVs, such as abstract light signals presented by LED-light bars as a supplement to dHMI information (i.e., external Human-Machine Interface; eHMI), were investigated within the thesis. Overall, three studies were conducted. Study I aimed on deriving manual drivers' GA parameters for initiating parking maneuvers in shared spaces when encountering interaction partners as a basis for intuitive AV driving functions. Study II investigated participants' assessment of eHMI signals as potential means of communication in AVs by a Wizard-of-Oz approach. A seat suit covered the driver of a test vehicle to simulate an AV. A light bar was placed on top of the test vehicle's roof presenting abstract light signals for communicating with surrounding pedestrians in a shared space setting. In addition, study III explored the effect of contradictory information sent by the interaction vehicle's movements as dHMI information and abstract eHMI signals. The contradictory information might have led to potentially safety critical encounters for surrounding pedestrians. The results revealed that there is not one unique parameter value when considering GA in traffic flow for initiating parking maneuvers. Rather, there are several influencing factors, such as the interaction partners' speed, that affected GA when coordinating encounters. According to the revealed results, it can be concluded that dHMI parameters in AVs should be orientated on manual driving parameters to provide intuitive and transparent encounters. Further studies need to investigate additional influencing factors and their specific effect on dHMI parameters in more detail with regard to intuitive driving functions in AVs. The results for eHMI signals as potential means of communication in AVs revealed that these signals suffer from intuitive intelligibility. Previous knowledge about the signals' assigned meanings would be required to support interactions with surrounding road users. Thus, training or information campaigns considering eHMIs should be provided to potential incidental users if these signals are prospectively applied as means of communication in AVs. Contradictory information provided by dHMI and eHMI signals of an interaction vehicle, potentially leading to safety critical encounters, impaired participants' system assessment regarding trust, acceptance and subjective feeling of safety during encounters. Given the results, it can be concluded that dHMI and eHMI information need to be in line with each other if applied in AVs to prevent from confusion of surrounding road users and to support road safety and efficiency. Overall, the revealed results of the conducted studies might be respected when developing a holistic HMI for AVs when interacting with manual road users.

Effects of Rearward Countdown Displays in Highly Automated Shuttle Buses on Following Drivers

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Objective: This contribution investigates the potential of external HMIs (eHMIs) at the rear of highly automated shuttle buses (HASBs) to improve the interaction with following drivers.

Background: The use of HASBs is considered a promising concept to promote flexibility as well as sustainability in transportation and is currently extensively explored by various research projects. There is a consensus that HASBs need to be highly accepted for being successfully integrated into road traffic (Nordhoff et al., 2018; Paddeu et al., 2020). Until now, the behavior of HASBs is relatively unfamiliar to human drivers, since HASBs act novel and specific. For instance, HASBs currently drive at speed levels below 20 km/h, which is why traffic flow may be substantially impeded. This may result in an increased potential of frustration for drivers in rear traffic, which might lead to negative effects on driving behavior and road safety such as risky overtaking maneuvers. In the end, this could reduce the acceptance of HASBs.

Method: Therefore, an online video-based study was conducted to investigate how additional information about the next stop and thus a safe opportunity for overtaking the HASB is evaluated by following drivers and to what extent this improves the interaction with HASBs. In this context, different eHMIs in the form of countdown displays at the HASB's rear window were investigated. Video material was produced in Unity 3D displaying the perspective of manual drivers driving behind a HASB. In a repeated-measures

design, countdown displays that differed in a) *mode* (“time“ versus “distance“ to the next stop) and b) *update frequency* (“1.0 Hz“, “0.5 Hz“, “0.2 Hz“, versus “0.1 Hz“) were examined and compared to a baseline condition without any countdown during the driving scenario. For instance, given that the HASB drove uniformly at a speed of 18 kilometers per hour in the recorded videos, an update frequency of 1.0 Hz corresponded to an update of the countdown every 5 meters to indicate the remaining distance to the next stop.

Results: Results showed that both modes were rated significantly better concerning understanding, predictability, perceived quality of information, and acceptance than the baseline. However, no significant differences were found between “time“ and “distance“. For update frequency, the repeated-measures ANOVAs showed that higher frequencies were generally preferred (“1.0 Hz“ or “0.5 Hz“). However, the consistently significant mode vs. update frequency interactions concerning all investigated criteria suggest a more complex relationship in this regard. Overall, “1.0 Hz“ received the highest ratings at the “time“ mode (updating every second), and “0.5 Hz“ at the “distance“ mode (updating every 10 meters).

Conclusion: In summary, the information provided by additional countdown eHMIs could increase the transparency of upcoming HASBs’ driving maneuvers for following traffic and thus support road safety. Still, the question of the exact parameters of mode and update frequency has not yet been definitively resolved.

Implications: A first important step towards an eHMI for following traffic of HASBs has been made. Further investigations are recommended, which could e.g. focus on different driving scenarios or investigation methods.

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Dissertation Exposé on Measuring Mental Workload for Cyclists

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Sustainable transportation alternatives to motorized transportation, such as cycling, can play a crucial role in reducing emissions and promoting sustainable mobility in urban areas. However, the limited adoption of cycling as a mode of transportation is a pressing issue, reflected in current research showing that certain demographics, such as women, the elderly, and people from low-income neighborhoods, hesitate to use bicycles due to safety concerns and factors related to comfort (Aldred et al., 2017; Andrews et al., 2018; Berghoefer & Vollrath, 2022; Mahne-Bieder et al., 2020; Pearson et al., 2023; Trapp et al., 2011). Previous research has likewise demonstrated the pivotal role of mental comfort in cyclists' route choices (Berghoefer & Vollrath, 2022). Therefore, when aiming to increase the modal split of cyclists, it becomes imperative to explore strategies that enhance the overall comfort and safety of the bicycle trip. To do that, it is essential to gain a comprehensive understanding of the cognitive factors that contribute to cyclists' safety and mental comfort. The cognitive demands of cycling encompass a wide range of factors that influence a cyclist's ability to navigate their environment and make informed decisions. These demands include the cognitive capacity required to process visual and auditory stimuli, assess potential hazards, and respond promptly to changing situations.

The theoretical foundation of this thesis is rooted in the concept of mental workload, as it allows to gain an understanding for the amount of cognitive resources being used while cycling. Workload encompasses the mental effort required to accomplish a task and is influenced by various factors, including task complexity, information processing requirements, and time constraints

(Longo et al., 2022). When workload exceeds an individual's capacity, their ability to perceive, process, and respond to traffic situations may be compromised, leading to errors and, consequently, accidents.

For this thesis, three studies will be conducted consecutively. The first study aims to find suitable physiological correlates of mental workload while cycling by manipulating workload through a secondary task. The second study will then utilize these physiological measures to evaluate the workload for external factors (e.g. infrastructure type, traffic volume or others). In a third study, personal factors will be evaluated to determine their influence on mental workload.

By applying workload measures, this research aims to evaluate the cycling task and its surrounding factors based on the cognitive workload perceived by cyclists. The objective is to identify areas of the cycling domain that can be enhanced to make cycling a safer and more comfortable mode of transportation for all individuals.

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How Can Technology Acceptance Be Measured? An Adaptable Toolkit for Measuring Acceptance of Experience-Oriented Technologies

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When developing new technological innovations, it is essential to include users' perceptions for a successful implementation. However, no consensus has been reached on a standardized measurement procedure for technology acceptance – let alone a unified definition (Quiring, 2006). There are various theoretical models and different methods to measure acceptance, ranging from attitude to behavioral intention to more tangible approaches such as actual usage (Hüsing et al., 2002). While prevalent methods – for example the scale by Van Der Laan et al., 1997 – enable a quick assessment of usefulness and satisfaction, they do not capture all dimensions of acceptance (Adell, 2007). Therefore, combining several methods that collect subjective and objective data is necessary for a comprehensive evaluation (Kistler, 2005).

Technology acceptance plays a role in various fields of application. Established models that originated in the context of working environments such as the Technology Acceptance Model (TAM; Davis, 1985) or the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) provide a solid foundation for current research approaches (Alomary & Woollard, 2015). However, new technologies surpassing the professional life pose different challenges. When it comes to interactive technologies, people must enjoy using them since a pleasant experience motivates repeated usage (Diefenbach & Hassenzahl, 2017). Hence the focus of the dissertation is on the acceptance of experience-oriented technologies.

The aim is to propose a general procedure for acceptance measurement with adaptations for different fields of application to identify obstacles and derive implications for development and design. Therefore, a toolkit divided into modules on a general as well as technology-specific level that combines various methodologies to measure technology acceptance is to be developed. Possible fields of application include hedonistic technologies for entertainment, relatedness-technologies, which enable connectedness to other people via distance, as well as the automotive industry and the health sector.

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Die Wahrnehmung über Augenbewegungen hinweg

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In diesem Moment springt ihr Blick von einem Buchstaben zum anderen und fixiert einzelne Wörter. Diese sprunghaften Blick- oder Augenbewegungen nennt man Sakkaden. In den meisten Fällen dienen Sakkaden dazu, die Fovea, den schärfsten Punkt des Sehens, auf ein relevantes Ziel zu richten, um detailreichere Information vom Ziel zu gewinnen (z. B. einzelne Buchstaben erkennen). Diese schnellen Sprünge des Augapfels bringen allerdings auch die Tatsache mit sich, dass die Information auf der Netzhaut während der Augenbewegung stark verzerrt ist. Auch Veränderungen, die während einer Sakkade im Ziel passieren, werden nur schwer erkannt (Bridgeman et al., 1975; Hübner, 2021).

Sakkaden zählen zu den schnellsten Augenbewegungen mit Dauern von weniger als 20 Millisekunden (Gibaldi & Sabatini, 2021). Für die zeitnahe Detektion von Sakkaden werden demzufolge hochauflösende Eye-Tracker verwendet. Gleichzeitig braucht es einen schnell-reagierenden Monitor, der den präsentierten Stimulus noch während der detektierten Sakkade ändern kann. Nach der Ausführung einer Sakkade beurteilen die Versuchspersonen mittels Knopfdrucks, in welche Richtung eine Veränderung im Stimulus stattgefunden hat. Aus den Antworten für eine Reihe von verschiedenen Veränderungsausprägungen, kann dann die Genauigkeit der trans-sakkadischen Wahrnehmung und eine mögliche bevorzugte Richtung (Bias) ermittelt werden.

In meiner Dissertation möchte ich der Frage nachgehen, von welchen Faktoren die Veränderungswahrnehmung über eine Sakkade hinweg abhängt. Diese Faktoren beinhalten beispielsweise die unterschiedliche Verarbeitung der visuellen Information zwischen Peripherie und Fovea. Ich plane, verschiedene

Eigenschaften des Sakkadenziels, wie Farbe und Orientierung, zu variieren. Dabei möchte ich messen, wie andere, einhergehende Veränderungen (beispielsweise in der Position des Stimulus) über Sakkaden hinweg wahrgenommen werden. Im Fokus meiner Untersuchung stehen visuell komplexe Stimuli, da die meisten bisherigen Erkenntnisse zum Thema auf stark vereinfachten und abstrakten Stimuli beruhen, wie beispielsweise Punktwolken (Hübner, 2021). Um den Erkenntnisgewinn näher an die angewandte Forschung zu bringen, möchte ich untersuchen, ob komplexere Stimuli oder sogar realitätsnahe Objekte einen Unterschied in der trans-sakkadischen Wahrnehmung ausmachen.

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The Role of Territorial Behavior in Shaping User Engagement on Enterprise Collaboration Platforms

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The importance of ownership, control, and identification with specific resources is emphasized by the theory of territoriality in organizations (Brown et al., 2005; Pierce et al., 2003). Individual territorial behavior in the context of enterprise collaboration platforms refers to employees actively taking ownership and providing or protecting information or ideas by using platforms (Chen et al., 2023; Hobfoll, 1989). Supporting and acknowledging such conduct through collaboration platforms may foster user engagement by instilling a sense of autonomy, competence, and relatedness. This aligns with the Self-Determination Theory (SDT), which implies that people have fundamental psychological requirements for autonomy, competence, and relatedness. According to the notion, when these requirements are met, people are more intrinsically motivated and engaged (Ryan & Deci, 2000). The communication, coordination, cooperation, and content management functionality of enterprise collaboration platforms can help to fulfill these psychological demands, thereby increasing user engagement.

This paper aims to explore the potential interaction between individual territorial behavior and the use of enterprise collaboration platforms, influencing the association between platform functionality, intrinsic need satisfaction, and user engagement. We conducted an empirical study with data collected from 170 employees from different organizations. Using Hayes' PROCESS in RStudio (Hayes, 2022; *R Core Team, version 4.3.1*, 2023), we analyzed the link between platform functionality, intrinsic need satisfaction, and user engagement. The findings revealed an interaction effect and a mediating role of intrinsic need satisfaction in understanding the relationship between platform functionality, territorial behavior, and user engagement. The interaction effect between the usage frequency of platform functionality and territorial behavior of marking and defending was significant, suggesting that the relation between the use of platforms and intrinsic need satisfaction depended on the level of territorial behavior of marking and defending. When territorial behavior of marking and defending was low, higher levels of use of platforms were associated with increased levels of intrinsic need satisfaction. However, when territorial behavior of marking and defending was high, higher levels of use of platforms were associated with decreased levels of intrinsic need satisfaction. Moreover, the indirect effects of usage frequency of platform functionality on user engagement through intrinsic need satisfaction were significant. The magnitude and direction of the indirect effects varied depending on the level of territorial behavior of marking and defending. Likewise, when territorial behavior of marking and defending was low, higher levels of use of platforms were associated with increased levels of user engagement through intrinsic need satisfaction. However, when territorial behavior of marking and defending was high, higher levels of use of platforms were associated with decreased levels of user engagement through intrinsic need satisfaction. In conclusion, employees showing lower levels of territorial behavior of marking and defending were more likely to utilize the collaboration platform functionality of communication, coordination, cooperation, and content management in their work. This increased usage of platform functionality strengthened their intrinsic need satisfaction, fostering intrinsic motivation and resulting in enhanced user engagement.

Our research contributes to the understanding of how individual territorial behavior, platform functionality, and intrinsic need satisfaction shape user engagement in intra-organizational collaboration. The results emphasize the importance of considering the interplay between territorial behavior and the use of platforms in fostering user engagement. These insights have practical implications for organizations seeking to optimize collaboration platforms to enhance employee engagement.

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Physiological Measures as Predictors of Human Task Performance in Supervisory Process Control Tasks: A PhD Outline

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The large-scale integration of digital manufacturing technologies in smart factories is expected to shift the role of human operators from largely manual labor towards the supervision of complex cyber-physical production systems (Kadir et al., 2019; Neumann et al., 2021; Rauch et al., 2020). In these supervisory process control tasks, operators will interact with highly automated systems, introducing the risk of well-known pitfalls of human-automation interaction. These include operators being out-of-the-loop and having to deal with peaks in task demand in the event of system failures (Endsley, 2017; Onnasch et al., 2014).

A promising approach to mitigate these issues is the use of physiological measures to assess the mental state of human operators (Charles & Nixon, 2019; Tao et al., 2019) as a basis for dynamic task allocation between the human and the system (Oppermann, 1994; Scerbo, 2001). The idea is to use physiological measures to capture the operator's individual response to cognitive task demands and other task characteristics in order to predict the operator's current ability to perform the task (Longo et al., 2022; Wickens, 2017). Establishing such predictions would allow for a dynamic reallocation of task responsibilities depending on both individual and situational factors. To lay the groundwork for such an approach, this PhD project investigates the following main research question: To what extent can human task performance in supervisory process control tasks be predicted by assessing the human's mental state using physiological measures?

As a first step to address the main research question, the current state of research on the use of physiological measures for the assessment of operators' mental state in supervisory process control tasks has been analyzed in a scoping review, following the PRISMA-ScR guidelines (Tricco et al., 2018). The review identified ocular (primarily pupil diameter) and electrocardiac (primarily heart rate variability) measures as the most prominent measurement approaches in the research area, and mental workload, mental fatigue, and vigilance as the primary mental state dimensions of interest. The latter highlighted the existing research focus on investigating the mental effort invested by operators as a function of both cognitive task demands and time on task. Furthermore, the review showed that most related research has aimed to validate physiological measures for assessing cognitive task demands and time on task, or applied them for evaluation purposes. In contrast, only a minority of research has examined their applicability as predictors of human task performance.

The resulting research gap is currently being addressed in a first laboratory study that examines the physiological measures pupil diameter and heart rate variability as predictors of human task performance in a process monitoring task. The three independent variables of task demand, time on task, and task reward are used in a within-subject design to manipulate the mental effort invested by study participants, which in turn is expected to affect participants' task performance, i.e., their response times to critical system conditions. The goal of the study is to examine whether the physiological measures are reliable correlates of mental effort, thereby providing insight into participants' individual response to the manipulation of task characteristics, and hence can account for intra-individual variance in task performance. Moreover, the study investigates how the different characteristics influence the relationship between physiological measures and task performance.

The results of the first laboratory study are intended to provide the basis for future studies that will extend the analysis to other types of monitoring and more complex supervisory control tasks, including additional human performance metrics. Taken together, the collection of empirical evidence planned in this PhD project aims to advance the understanding of the relationship between physiological measures of human mental state and observable human task performance. Based on this, it is intended to contribute to the application of physiological measures in facilitating human-centered automation interaction in supervisory process control settings.

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Human-AI Interaction: The Effect of Anthropomorphism on Trust in AI-Agents

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Artificial intelligence (AI) has become an integral part of everyday life, it is ubiquitous. This raises the question of how AI can support employees in the work environment. AI is helpful where large amounts of data are processed. Monitoring activities - especially in control rooms - require the processing of large amounts of data in a dynamic system, which can lead to critical decisions under uncertainty. For an AI system to be supportive and useful, it should be trustworthy and easy to use.

Anthropomorphism is defined as the tendency to attribute human characteristics to non-human agents (Epley et al., 2007). As a design-principle, human-like design has been found to allow for more natural interaction, higher user acceptance and trust (Cohen et al., 2021; Jensen et al., 2021). However, over-trust can lead to complacency and misuse, while under-trust can lead to disuse (Parasuraman et al., 1993; Parasuraman & Riley, 1997). Both have potentially negative effects on both employee and work system performance.

Interpersonal trust is defined as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that party" (Mayer et al., 1995, p. 712). The aspect of vulnerability can also be found in the context of trust in automation, where trust is described as "the attitude that an agent will help achieve an individual's goals in a situation characterized by uncertainty and vulnerability" (Lee

& See, 2004, p. 54).

Therefore, the aim of this PhD project is to investigate the relationship between anthropomorphism and trust. The focus will be on moderating factors such as age, gender, affinity for technology and other personality traits. The questions will be explored in a work-related context in order to draw conclusions on safety-related issues as well as long-term concepts such as employee health and well-being.

The research involves several online and laboratory-based studies, the exact operationalisation of which remains to be determined. An online pilot study is considered as a proof of concept to test possible manipulations of the design variants of AI agents. This would be followed by a laboratory study to investigate the relationship between anthropomorphism and trust, which would/shall be extended in a/the second laboratory study to include the factor of increased workload. A possible adaptive design of the agent could be the subject of the third study. An actual and realistic laboratory setting will be sought to increase ecological validity. A multimodal approach is envisaged with questionnaires such as an adapted version of the Godspeed questionnaires (Bartneck et al., 2009) to measure the perception of an agent in terms of anthropomorphism, animacy or perceived intelligence. Affinity for technology interaction as a general interaction style should be assessed using ATI-scale (Franke et al., 2018).

The choice of independent and dependent variables, as well as their operationalisation, has not yet been finalised and will be discussed. This could also be done on the basis of a preceding systematic review to provide a theoretical framework as an overview and foundation. Thus, this PhD project deals with the relationship between anthropomorphism and trust in a supporting AI system, using a work-related context as an example. As the project is still in its early stages, the exact design of the studies as well as the selection and operationalisation of the target variables have yet to be finalised. For example, the exact characteristics of the AI agent and the level of anthropomorphism need to be addressed. This will depend strongly on the context and the application domain of the system. Particularly relevant will be the comparison of human-human and human-AI interaction, and what expectations are placed on the agent. How do users respond to agent's errors? Some of these open questions could also be the subject of discussion during the Summer School.

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Implementing a Multi-Robot Solution in Ship Inspection and Maintenance. The Role of Human Factors Exemplified Within the BUGWRIGHT2 Project.

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Objective: The poster presents the roles, roadmap, and lessons learned regarding human factors within BUGWRIGHT2, a current interdisciplinary project funded by the European Union's Horizon 2020 research and innovation program (Grant Agreement No. 871260). The project aims to stimulate digital-maritime transformation by developing a multi-robot solution for ship inspection and maintenance including also virtual and augmented reality.

Background: To unleash the full potential of robotic solutions in the field, human factors (e.g., system trust, Pastra et al., 2022; Schaefer et al., 2016) need to be considered in user interface design and evaluation (Gründling et al., 2023), technology implementation and acceptance (Venkatesh et al., 2016) as well as personnel development (Paruzel et al., 2019).

Method: First, we conducted multi-method work analyses (e.g., Grote et al., 2000) to elaborate on the current and prospective target task and to identify expectations and requirements of inspectors in human-robot teams using interviews and field observations. Second, user interfaces were developed and evaluated in iterative loops with end-users on-site (Gründling et al., 2023), integrating insights from the work analyses. Third, theoretical and scientific knowledge from human resources and change management (e.g., Schlicher et al., 2020) are compiled and extended to guide market introduction and practitioners involved in the project.

Results: Critical factors within the task (e.g., process, roles), human (e.g., control, system trust, cognitive load), technological bricks (e.g., level of autonomy, reliability), and organizational context (e.g., legal implications) emerged that were considered in user interface design. Qualitative and quantitative end-user usability feedback (e.g., based on ISONORM 9241/10) continuously improved and influenced the user interface design process from prototypes to mock-ups. Skill profiles including technical skills and knowledge (e.g., feature knowledge), as well as nontechnical skills (e.g., ability to learn, communication), are incorporated into an overarching human resource concept.

Conclusion: Implementing multi-robot solutions in the field is a change process that transforms existing work processes and impacts human tasks, roles, and responsibilities. Human factors impact the success of technology implementation throughout the entire change process (i.e., unfreezing, change, freezing). Its findings do not act in a vacuum but radiate and influence technological bricks and organizational contexts.

Application/Implication: From the approach and findings of BUGWRIGHT2, two overarching lessons learned for future research and application projects can be derived.

First, interdisciplinarity including heterogeneous perspectives, priorities, and terminology challenges the implementation of multi-robot systems. Concepts, methods, and tools of human factors and work psychology offer a value basis to synchronize mental models (e.g., task-specific elaboration and visualization), guide interdisciplinary projects, and combine different perspectives. In this role, human factors as a field should be more visible and self-confident presented.

Second, single human factors are researched extensively (e.g., system trust, level of autonomy). However, much is also not yet known. Application projects highlight new research fields and blind spots in human factors research that should be examined thoroughly in experimental and field research (e.g., sociodigital self-comparisons in human-robot interaction, Ellwart et al., 2022).

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Teleoperierte Zugverbindungen im 5G Mobilfunknetz

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Teleoperierte und automatisierte Zugsysteme (GoA 3) können als Rückfallebene und für die technische Aufsicht einen bedeutenden Schritt für zukünftig hochautomatisierte Zugverbindungen (GoA 4) darstellen. Remote Operator sind dabei Triebfahrzeugführende, die den Zug über eine 5G Verbindung steuern und sich mit einem Zugassistenzsystem (ATO) Aufgaben teilen. Ideen für die Umsetzung werden für die Fahrt auf Sicht (Pacaux-Lemoine et al., 2020) und die Zuschaltung des Remote Operators bei kritischen Situationen (Grippenkoven et al., 2020) beschrieben und sollen nun empirisch untersucht werden. Neben der Spezifikation des HMI wird auch die Zusammenarbeit und Aufgabenübernahme des ATO erläutert. Die Leistung des Remote Operators und die Ermüdungserscheinungen durch die Überwachung automatisierter Systeme (Brandenburger et al., 2017) werden dabei im Fokus stehen.

Ziel dieser Studie ist es, ein bereits entwickeltes Human-Machine-Cooperation System Model (Pacaux-Lemoine et al., 2020) im Kontext von teleoperierten Zugfahren mit empirisch überprüfbaren Daten (Reaktionszeitenmessung in einer Wahrnehmungs-Reaktionssaufgabe) zu überprüfen. Die $N = 25$ Versuchspersonen (Personen ab 18 Jahren ohne besondere Zugangsvoraussetzungen) werden aufgezeichnete Simulationen einer ferngesteuerten Zugfahrt betrachten, nachdem ein Alarmsignal des Zugassistenzsystems ertönte. Erkennen die Probanden einen Baum auf dem Gleis, soll so schnell wie möglich ein Knopf gedrückt werden. Insgesamt werden 35 DurchlÃ¤ufe (27 mit Objekt, 8 ohne Objekt) in randomisierter Reihenfolge präsentiert. Die Distanz vom Zug zum Objekt und die Geschwindigkeit des Zuges werden systematisch variiert, zudem erfolgt eine dreifache Messwiederholung. Durch die Informationsverarbeitung im Assistenzsystem, die Übertragung im 5G Netz, und die menschliche Informationsverarbeitung entstehen Verzögerungszeiten, die möglicherweise zu verspäteten oder zu langsamen Entscheidungen führen können. In diesem Zusammenhang soll die Veränderungsblindheit betrachtet werden, die durch den Wechsel von Assistenzsystem an Remote Operator entstehen kann (Simons et al., 2000). Mögliche Lösungsansätze sollen dann in einer Folgestudie diskutiert und untersucht werden. Dieses Poster stellt den aktuellen Stand meines Promotionsvorhabens dar, welches im Juni 2023 begonnen wurde. Ziel der Promotion ist es, teleoperierte Zugfahrten im 5G Netz aus Human Factors Sicht zu untersuchen.

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Der Arbeitsplatz der Technischen Aufsicht: Nutzerzentriertes Design und Evaluierung eines Remote-Operation-HMIs

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Die Mobilität der Zukunft wird maßgeblich durch das hochautomatisierte Fahren (ab SAE-Automatisierungslevel 4) geprägt sein. Die Remote Operation von Fahrzeugen stellt einen Ansatz dar, der hochautomatisiertes Fahren bereits in einem Entwicklungsstadium nutzt, in dem das System auf menschliche Unterstützung angewiesen ist. Ein hoher Grad an Sicherheit und Verfügbarkeit wird durch einen menschlichen Operator gewährleistet, der das Fahrzeug aus der Ferne bei Fahraufgaben unterstützt, welche die Fähigkeiten der Fahrzeugautomatisierung übersteigen. Der Remote Operator erfüllt damit die gesetzlichen Anforderungen an eine Technische Aufsicht zur Gewährleistung eines sicheren Betriebs hochautomatisierter Fahrzeuge wie im 2021 novellierten Straßenverkehrsgesetz beschrieben. Zur Integration des Remote Operators in das automatisierte Fahrsystem wurde eine neuartige nutzerzentrierte Mensch-Maschine-Schnittstelle (HMI) für die Remote Operation entwickelt. Sie ist zugeschnitten auf die Fernunterstützung eines hochautomatisierten Shuttles, beispielsweise von einer Leitstelle des Öffentlichen Personennahverkehrs (ÖPNV) aus, und basiert auf einer systematischen Analyse von Anwendungsfällen, von denen detaillierte Anforderungen abgeleitet wurden. Auf Basis der Anforderungen wurde zunächst ein Paper-Pencil-Prototyp erstellt. Im nächsten Schritt wurde ein Klick-Dummy gestaltet und anhand realitätsnaher Szenarien von Leitstellenmitarbeitenden evaluiert (Kettwich et al., 2021).

Die hierbei gewonnenen Erkenntnisse flossen in den Aufbau eines prototypischen Remote-Operation-Arbeitsplatzes ein. Dieser wurde von $N = 34$ Versuchspersonen, die die Kriterien zum beruflichen Hintergrund für die Rolle der Technischen Aufsicht erfüllen, anhand von für die Remote Operation als typisch identifizierten Simulationsszenarien getestet. Um eine zusätzlich zur Remote Operation anfallende Arbeitsbelastung darstellen zu können, wurde über eine Zweitaufgabe systematisch die Höhe an zusätzlichem Workload variiert. In Ergänzung zu Maßen der Akzeptanz und der Gebrauchstauglichkeit wurden objektive sowie subjektive Indikatoren der Performanz, Fehleranfälligkeit, Arbeitsbelastung und des Situationsbewusstseins erhoben. Qualitative Rückmeldungen zu Verbesserungsmöglichkeiten rundeten die Nutzendenstudie ab. Auch unter erhöhtem Workload lag die subjektiv empfundene Belastung im mittleren Bereich. Das berichtete Situationsbewusstsein unterschied sich nicht signifikant zwischen den Workload-Bedingungen. Besonders zufrieden waren die Teilnehmenden mit der übersichtlichkeit und Ergonomie des Arbeitsplatzes sowie mit dem Interaktionsdesign zur Unterstützung der Fahrzeugautomation. Die Ergebnisse der Studie liefern wertvolle Informationen für die iterative Weiterentwicklung des Arbeitsplatzes der Technischen Aufsicht sowie für die weitere Forschung zur Remote Operation automatisierter Fahrzeuge.

Schlüsselwörter: Mensch-Maschine-Interaktion, Remote Operation, Technische Aufsicht, automatisiertes Fahren, nutzerzentriertes Design, Arbeitsplatzgestaltung, Situationsbewusstsein, Workload

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CoboTank: Mental workload in human-robot interaction

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With 90% of the world's cargo transported by a fleet of 90,000 ships, the maritime sector stands as the most vital mode of transport globally (German Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, 2023). Despite being one of the oldest and most traditional sectors, the maritime industry is witnessing an increasing integration of technology (Munim et al., 2020). However, progress in enhancing safety has not curbed the persistently high number of accidents, with human error remaining the principal cause (EMSA, 2021). The significant prevalence of human error can be primarily attributed to the mental workload endured by operators while interacting with complex systems (Yan et al., 2022). With diminishing ship crews, the "CoboTank" project aims to develop a collaborative robot system that requires fewer operators for the loading and unloading of liquid cargo ships. This process presents significant challenges due to time constraints, handling of hazardous chemicals, and the physical demands on workers. These harsh working conditions have led to early retirements, high sick leave rates, and recruitment difficulties.

Furthermore, robots have become integral to modern workplaces, performing various tasks across industries like medicine, agriculture, and manufacturing (Ötting et al., 2022). While robots offer advantages in terms of speed, force, and precision, their limited capabilities and the need for customization often pose technical challenges when attempting to automate entire work processes (Bogue, 2009; Mital & Pennathur, 2004; Niknam et al., 2018; Pagilla & Yu, 2001). To address this issue, the concept of human-robot shared workstations, especially with collaborative robots (cobots), has gained prominence

(Steil & Maier, 2017). Cobots are designed to work alongside humans, leveraging their cognitive abilities while benefiting from the robots' strength and precision (Buxbaum, 2020).

In response to these developments, research on human-robot interaction (HRI) has focused on understanding and designing effective collaboration between operators and robots, taking into account factors such as trust, experience, anxiety, and workload (Goodrich, Schultz, et al., 2008; Prati et al., 2021). Additionally, adhering to standards such as DIN EN ISO 9241 for ergonomic workplace design (ISO, 2019) and focusing on usability principles like self-descriptiveness and error tolerance are vital for ensuring intuitive and safe operation of cobots.

The evolving cobot in the CoboTank project is designed to handle heavy loads during the hose mounting and dismounting process, while the operator manually guides and connects hoses for precise placement and subsequent thread screwing. The research in this project focuses on evaluating the physical and mental workload experienced during the loading and unloading process and developing a cobot system to assist workers in harbors. Objective measurements such as dynamometers and eye tracking, along with subjective assessments, will be used to evaluate the physical and mental workload in the current non-automated situation. Furthermore, while previous studies have primarily focused on mental overload, there is a growing need to address situations of vigilance and underchallenged tasks resulting from increased automation (Cummings et al., 2016; Pattyn et al., 2008). Boredom and vigilance have significant implications for task performance and safety. Therefore, investigating how specific design features and robot autonomy influence mental workload is crucial.

To prioritize good usability and ensure a positive user experience, the control element (interface) attached to the cobot will follow the approach presented by Prati et al., 2021, which systematically integrates operator requirements into interface development. This approach will be adapted from the industrial context to the maritime context. Additionally, the control element will adhere to the dialogue principles outlined in DIN EN ISO 9241, and different design options will undergo evaluation through user testing. To comprehensively capture the effects of design on workload, operators will be provided with different degrees of autonomy through the interface, aiming to avoid both underload and overload. The results of the study will be used to evaluate the prototype of the cobot by simulating a loading and unloading process with and without the cobot. Physical and mental workload will be compared between the two scenarios.

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Influences of hand-arm vibration on human cognition

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Within this poster presentation I would like to present and discuss our planned research program on the influences of hand-arm vibration on cognitive performance. Hand-arm-vibration emerges almost always when using hand craft tools. More importantly, in many cases the vibration cannot be avoided nor can the handicraft activities be replaced by other technologies as the expertise of the craftsmen are of much importance for those tasks (e.g., grinding, drilling). But especially in those cases, it is essential for the craftsmen to be attentive in order to avoid accidents or damages. To provide technical assistance for craftsmen, to improve performance effectively, and in the best case to form a symbiosis (Inga et al., 2023) between the human worker and those tools, it is necessary in a first step to investigate the challenges and advantages of hand-arm vibration on cognition.

However, so far there exists only few studies investigating the impact of hand-arm vibration on cognitive functioning. One study that assessed bus drivers' performance on a Stroop task after a full work day found that the experienced acceleration of hand-arm vibration during the day predicted the drivers' interference time. The higher the hand-arm vibration acceleration, the higher was the resulting interference time (Rahmani et al., 2021). Additionally, there exists some research investigating the impact of whole-body vibration on cognition. Those studies found evidence for an improvement of the performance in a Stroop task (Regterschot et al., 2014) but also impairments in attention and concentration in complex tasks (Gritschmeier, 2021). However, the investigation of whole-body vibration is often motivated by the impacts of whole-body

vibration as a training method that stimulates the human neuromuscular system (Wen et al., 2023). Therefore, most studies investigate the performance in cognitive tasks after a session of two to four minutes in which the participants experience whole-body vibration. A scenario that is less realistic for vibration experienced by craftsmen when using hand craft tools.
Therefore, the aim of our line of research is to investigate the cognitive performance while at the same time experiencing hand-arm vibration. As the type of the vibration intensity (being constant, changing predictably, or changing unpredictably) might influence cognitive abilities, our first aim is to investigate which changes in vibration intensity affect cognitive performance most. In a second step, we aim to investigate the impacts of hand-arm vibration on the perceived task difficulty as well as on the desire to quit the current task and continue with a different task.

Keywords: hand-arm vibration, cognitive performance

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Camera-monitor systems and rearward perception in automobiles

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Camera-monitor systems (CMS) have the potential to revolutionize rearward viewing conditions for drivers, offering opportunities to optimize viewing angles and fields of view. This study investigates the use of CMS to compensate for perceptual errors in time-to-contact (TTC) estimation, specifically for accelerating vehicles. Previous research has shown that observers often fail to adequately consider acceleration when estimating TTC, leading to misestimations and potential safety hazards. We propose leveraging the size-arrival effect, a robust phenomenon where larger objects are perceived to arrive earlier, to enhance the mirror image in CMS and improve TTC estimation accuracy.

Two experiments were conducted to examine the feasibility of this approach, using a prediction motion paradigm. In the first experiment, participants were presented with positively accelerated and constant-speed car approaches within the CMS, with different kinds of vehicle size enhancements in the mirror image. Based on the results of the first experiment, the most effective enhancements were selected for implementation in the second experiment. This experiment additionally investigated the effect of vehicle size adjustment for negative accelerations.

The results suggest that manipulating the displayed size of an approaching vehicle based on its acceleration can improve the accuracy of TTC estimation in CMS. This can highlight the potential of mirror image enhancement within CMS to compensate for perceptual errors in TTC estimation. Implementing such a technique in CMS could enhance road safety by providing more reliable information to drivers and assisting in making informed driving decisions. Further research and development in this area can contribute to the advancement of driver-assistance systems and improve overall road safety.

The Role of Psychological Basic Need Satisfaction in Seafarers' Utilization of Energy-Efficiency Decision Support Systems and Preference for Automation

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Objective: In this early draft overview of my dissertation, I integrate the findings of two studies, as well as a proposal for a third study. The overall objective of this research is to understand the role of psychological basic need satisfaction (with a primary focus on autonomy) in seafarers' utilization of energy efficiency decision support systems and to determine which factors affect their preference for automation types.

Background: Approximately 3% of the world's carbon output is attributed to the shipping industry, and an increase of 50% can be expected by 2050, endangering global emissions goals (International Maritime Organization (IMO), 2021). As 70–80% of the energy of cargo ships is used for ship propulsion, decision support systems (DSS) onboard could aid in energy-efficient routing of shipping vessels (e.g., through slow steaming or weather routing). However, the integration of such tools into the working environment of seafarers is a central challenge to an industry faced with an energy efficiency gap (cf. e.g. Acciaro et al., 2013; Johnson and Andersson, 2011). Critically, research suggests that seafarers perceive having low influence on operations onboard (Zoubir et al., 2023), which may inhibit their satisfaction of the need for autonomy (in the sense of Psychological Basic Needs mini-theory of Self-Determination Theory, cf. e.g. Deci and Ryan, 2012). It is unclear to what extent a DSS utilizing automation could be perceived as further reducing autonomy need satisfaction and how this may affect preferences for automation in general or for specific

automation types.

Study 1 – Method: My first study sought to identify specific route planning tasks suitable for DSS, as well as seafarers' basic psychological need satisfaction at work. In a mixed-methods study, I conducted a hierarchical task analysis of energy-efficient route planning based on an analysis of manuals and expert interviews. In an online survey of seafarers ($N = 45$), I utilized an expectancy-value-cost framework (cf. e.g. Fowler et al., 2021) to identify tasks with high potential (e.g., high value but low success expectancy) tasks. A newly developed questionnaire, the "Preference for Automation Types Scale" (PATS) which applies Parasuraman et al., 2000's framework, was also implemented.

Study 1 – Results: I identified that tasks with the greatest potential for support by a DSS utilized spatial information (e.g., forecasts of tides, tidal streams, or wind) and could be integrated (e.g., through the use of overlays). Satisfaction of the need for autonomy was significantly lower than needs for competence and relatedness. PATS showed a preference for automated information acquisition and information analysis but human decision selection and action implementation. There was a significant negative correlation between autonomy need satisfaction and preference for automated decision selection with a small effect size, indicating that lower ratings of autonomy satisfaction coincided with a higher preference for the automation of decision selection.

Study 2 – Method: In a second study, I conducted evaluation studies in a ship's bridge simulator with seafarers ($N = 22$). Participants planned three routes: 1) with control software without automation ("OpenSeaMap", 2023), 2) with the MariData DSS, or 3) with the DSS while concurrently completing a navigation task. I assessed ratings of the task (e.g., workload), the tool used (usability, user experience, trust), psychological basic need satisfaction with technology usage, as well as PATS before and after study (and therefore DSS-interaction). Furthermore, we conducted interviews based on the critical decision method (CDM, cf. e.g. G. A. Klein et al., 1989).

Study 2 – Results: Workload and usability were rated similarly across all conditions, even in the double-task condition. Participants rated the hedonic user experience with the DSS in both conditions significantly higher than the control, and this was a large effect. Regarding psychological need satisfaction during technology usage, I found significantly higher ratings of autonomy satisfaction in the control condition (which didn't utilize automation) but lower ratings of relatedness to others, which were all moderate effects. Regarding PATS, there were small effects of decision selection and action implementation changing towards a preference for human control in pre-post comparisons, but this was non-significant. In the analysis of the CDM, we found that participants underlined the goal conflict of lowering fuel consumption with time constraints and safety.

Study 3 – Proposal: The final study in this series will be conducted as an experimental study in the field and will explore previous findings such as the negative correlation of autonomy and decision selection, which may indicate a wish for DSS automation to generate compromises to goal conflicts. In this study, seafarers will utilize versions of the MariData DSS, which will have been modified to include or exclude features that e.g., 1) support seafarers' autonomy and 2) support the resolution of goal conflicts. This study will include all variables measured in previous studies.

Conclusion/Implications: While a further study has yet to be conducted, research so far suggests best practices for the design of DSS for energy-efficient route planning onboard, based on the qualitative interview data (e.g. HTA and CDM interviews), as well as quantitative evaluation (e.g. usability and user-experience). These can be implemented in DSS designed to help mitigate emissions in shipping today but may have further implications for future maritime autonomous surface ships (MASS). Furthermore and more generally, this work will explore implications for the design of automated features in domains where users already face low levels of autonomy satisfaction.

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