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NEW PERSPECTIVES ON DIGITALIZATION: LOCAL ISSUES AND GLOBAL IMPACT

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Proceedings on Digitalization at the Institute for Advanced Study of the University of Siegen

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Preface

On April, 21 2020, the Insititut of Advanced Studies of the University of Siegen ("Forschungskolleg Siegen") hosted a virtual conference on digitization. While hosting a purely digital event is well suited for a conference that seeks to discuss topics at the edges of innovation, it was also triggered by the current Corona pandemic. Therefore, we hosted this conference online to put emphasis on new opportunities of digitalization and to demonstrate that every cloud has a silver lining.

The idea of this conference emerged as a follow-up of the FoKoS future award for scholars which was awarded in 2018. While the price is intended to acknowledge indiviual scholars and their research, the ambition was to put this idea one step further and organize an event from which more colleagues can benefit. For that reason, we decided to put a topic at the core which affects us all: *digitization*. Digitization is fundamental for several disciplines including philosophy, linguistics, mathematics, economics, architecture, healthcare and many more. Since digitization is fundamental for local acteurs including research institutes such as the University of Siegen and likewise for industry, it seems a perfect common theme for this conference.

The slogan of this conference is "Get together – think together" to highlight the significance to address important questions in inter- and transdisciplinary teams. While this is often proves a challenge in practice, it is all the more important to think beyond boundaries of distinct disciplines. This is particularily relevant when it comes to research areas that investigate the interplay between technology and human behavior. If those questions are not addressed from a holistic perspective, lots of hidden potentials remain uncovered.

Many scholars are already adressing specific questions whitout beeing aware of related research from scholars in other disciplines. In particular, PhD candidates could benefit from additional opportunities to get in touch with other scholars and exchange ideas and initiate collaboration to enhance their research. Since a great amount of academic work necessitates cooperation, e.g. to write proposals, papers and grant applications, this kind of conferences could be an important part of scientific communities.

For this volume, we are happy to include 15 research papers from 27 scholars and 4 different research institutes across all disciplines. We clustered the contributions in four sections: "Perspectives on Digital Health" (Part A), "Perspectives on Virtual Realities" (Part B), "Perspectives on Technology Use and Adoption" (Part C), and "Future Perspectives" (Part D).

Part A covers four articles that focus on aspects related to digital health. Harder and Chavez (*Digital Technology in Health Education? - Opportunities for New Mothers in Mexican Public Healthcare Services*) investigate potentials of digital technologies in healthcare with a particular focus on the Mexican system. Knop (*Methodological Implications of Research on Technology Use by Healthcare Professionals: A short Introduction to Multidimensional Scaling*) illustrates the potential of using multidimensional scaling for scholars doing research in the healthcare domain. Müller (*Exploring Emerging Patient Responsibilities in Telemedicine Use: An Empirical Study*) explores responsibilities that come with telemedicine, building upon insights from qualitative interviews. Finally, Uhde et al. (*Context Factors for Pro-Social Practices in Health Care*) reflect on context factors that are relevant when it comes to the healthcare system.

Part B consists of four contributions that are concerned with the role of virtual realitites. Ressing (*Combining the Virtual Reality with Biofeedback – State of Research in Nutrition*) reflects on potentials

of the combination of virtual realities and biofeedback. With a particular emphasis on eye-tracking, Schlechtinger (*What Are You Looking At? Using Eye Tracking to Improve Learning in Virtual Environments*) discusses opportunities for learning that can be exploited using virtual realities. Weber (*Exploring the Potential of Virtual Reality for Learning – A Systematic Literature Review*) adds to this debate by providing the results of a systematic literature review on the potentials of virtual realities with regard to learning. Finally, Weigel (*A Design Journey: Towards a Virtual Reality Simulation and Training Application*) proposes a more practical perspective on VR by outlining a design journey that supports the design and evaluation of a VR setting.

Part C addresses research questions related to technology adoption and use. Oschinsky et al. (*Resist, or not to Resist, that is the Question: On the Status Quo Bias of Public Sector Employees When Dealing with Technology*) reflect on the status quo bias and how this relates to technology resistance. Syed et al. (*From Technology Adoption to Organizational Resilience: A Current Research Perspective*) focus on the role of organizational resilience by reflecting on current research perspectives. Finally, Zeuge (*The Sweet Escape – A Research Agenda on Escapism in Information Systems Research*) suggests escapism as a new concept that can guide future scholars to better understand technology use.

Finally, we have gathered four papers with are more general approach in Part D ("Future Perspectives"). Kelter (*New Perspectives on Statistical Data Analysis: Challenges and Possibilities of Digitalization for Hypothesis Testing in Quantitative Research*) critically reflects how quantititative research is conducted, highlighting potentials for future research. Klein (*Reflective Practice in the Digital Age*) discusses how the concept of reflective practice can be applied in the digital age. Klesel and Henseler (*Emergence in Design Science Research*) suggest how the concept of Emergence can be used to evaluate design artifacts. Finally, Schäfer (*Developing a Smart City Strategy by use of St. Gallen Management Model focused in Smart Mobility and Smart Environment*) investigates how smart city strategies can be derived from established management models.

This conference was only possible with the support of many. We thank the Institute of Advanced Studies (FoKoS) for their support. In particular we thank Dr. Olaf Gauß, Vanessa Simon, Janine Taplan, Jonas Pees and Nick Brombach for ensuring a smooth conference. An academic conference only comes to life through the contributions of scholars. Therefore, we thank all the authors for submitting and presenting their research and for their active participation in the sessions. We hope that this collection contributes to a better dissemination of digitalization research across displinces and increases its visibility.

Jörg Radtke, Michael Klesel, Björn Niehaves

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Some Thoughts on Digitalization Research in Times of Corona

A Call for Universalization in Inter- and Transdisciplinary Research

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Keywords: Digitalization, COVID-19 Pandemic, Online Communication, Inter- and Transdisciplinarity, Scientific Collaboration

1 Opening Up the Debate

This volume gathers contributions to Siegen University's early-career scholars-conference on digitalization research, which fittingly was held online on April 21st, 2020.

In the following, I will elaborate on whether – and how – digitalization can be both the subject of and a challenge to inter- and transdisciplinary research. I first came up with the idea of said conference topic due to everyday experiences. When talking to colleagues about the subject, I quickly realized how popular research on digitalization is at our university – in fact, one might consider it a focus. Some research domains appear particularly likely to deal with digitalization, e.g. computer science, digital health and digital humanities, computational social science, research on sensors, robots and autonomous systems as well as studies on digital media. Certainly, today, digitalization research plays a crucial role in further fields of inquiry, for instance regarding virtual learning, architecture and spatial planning, art, philosophy, linguistics, literature studies or cognition science. Evidently, research on digitalization provides a common basis, which might enhance interdisciplinary understanding. However, this requires a shared language. To this end, which links can be made fruitful?

As any other line of research, digitalization research may place emphasis on content. The content, however, possibly consists of topics that constitute well-known subjects of study in the respective discipline. For example, I, as a political scientist, could examine the digitalization of a parliament (which is a common subject of analysis in political science). Perhaps, I would focus on modes of virtual communication (while ideally bearing in mind that communication research, again, represents an established academic field, whose rich foundations, next to other disciplines' bodies of research, may nowadays be complemented by insights from digitalization research) or on how the parliament is administered digitally. Likewise, insights from studies on social media appear relevant to political communication research, as social media gain importance for political communication. As the examples show, shared research subjects, structures and patterns emerge, which are of interest to multiple disciplines. Against this backdrop, future disciplinary analyses on digitalization may merely be specific variations, based on shared insight from various research domains. At Siegen University, such broad integration of academic disciplines is mirrored by the sheer existence as well as the work of the Special Collaborative Research Center on media and cooperation.

2 Disciplinarity vs. Interdisciplinarity and Transdisciplinarity

Indeed, it is the synopses of disciplinary work which render the frequent (yet all too often mostly symbolic) calls for inter- and transdisciplinary cooperation worthwhile. To stay with my former example: as a political scientist gathers results on digital communication processes in parliament, contrasting those with insights on digital communication from other research fields undoubtedly appears promising. Yet, as far as I am aware, to date, such meta-work occurs mostly in disciplinary contexts – I can read a review on digital political communication if I like to, but it will most likely employ a strictly political science focus. Naturally, linking results from multiple academic disciplines sensibly poses a major challenge. Still, I argue that establishing such linkages is likely to generate additional insight and might even be necessary to prevent parallelisms as well as unilateral thinking. As I learned from myriad discussions with colleagues working in other scientific fields than my own, surprisingly often, different approaches lead to strikingly similar outcomes. Specifically, I observed this during exchange with scholars working in media and communication research, spatial planning and psychology, which obviously constitute bodies of knowledge profoundly different from political science. Irrespective of said experiences, I am not trying to make a case for a single, unified, in some ways universal notion of science, as was formerly argued for in modern sciences' history (consider historical attempts to focus purely on essentials, such as radically placing emphasis on language in philosophy), yet never brought about remarkable success. Still, as a well-substantiated matter of fact, myriad congruent or at least very similar insights and conclusions can be found across multiple academic disciplines and papers published therein (Bhattacherjee & Fitzgerald, 2012; Buchanan, 2011; Henriette et al., 2015; Hunsinger et al., 2019; Orlikowski & Barley, 2001). In the course of disciplinary studies, however, individual findings are classified and interpreted by recourse to the given field's knowledge base, which consists of established conceptual work (such as theories, typologies and heuristics) as well as the empirical state of the art. Coming back to my former example, I, as a political scientist, would seek to link my results to parliamentary studies and fundamental work on political communication, albeit my insights could be decisively enriched by theoretical perspectives and findings from other disciplines and might, in turn, contribute to their progress as well. To date, such inter- and transdisciplinary linkages mark an exception to the rule. Undeniably, they pose a massive challenge to researchers, as in order to identify fruitful intersections, they need to be proficient in knowledge fields they have probably not studied themselves. Additionally, disciplinary prejudice and reluctance to engage in exchange prevent many such bridges from being built.

3 A Need for Universalization?

So, while interdisciplinary exchange bears considerable potential to enrich empirical findings, forward theory-building and ameliorate methodical approaches, to date, we lack strategies to broadly and lastingly establish such exchange processes, as this cannot be done by individual researches alone (and for some may even prove detrimental to their own career, e.g. regarding their disciplinary reputation). To encourage such profound mutual understanding, large entities and institutions – such as special collaborative research centers – appear as promising advocates. Still, up to now, their successes in fulfilling such hopes remain modest. While researchers from various disciplines do indeed collaborate to develop meta-frameworks, integrative conceptualizations and theories, their results are eventually received as individual pieces of work in disciplinary contexts. Thus, genuine interdisciplinary cooperation still awaits broad diffusion and institutionalization. Evidently, research disciplines constitute enclosed, self-sufficient systems operating by logics of their very own. Against this backdrop,

few, sporadic efforts to bridge such idiosyncratic modes seem unlikely to promote (and preserve) interdisciplinary resonance. Does, thus, the call for interdisciplinary collaboration merely echo the emphasis on discipline-transcending research as stressed by contemporary funding programmes?

Allowedly, scholars seeking to further interdisciplinary understanding are not facing an entirely new challenge. When today's sciences emerged, the humanities were at best frowned upon by the established natural sciences. At the time, natural scientific approaches predominated academic thinking, assuming that everything could be explained by universally applicable laws of nature. How the sciences' separation and continuing specialization would take effect was subject to much debate and speculation: would they, as they lost their common basis – that is, one shared notion of reality accepted by all – see an atomisation and fragmentation contrary to humanistic idea(l)s of comprehensive, integrated academic thinking, as postulated by the Humboldt brothers and other scholars of their time (Davies, 2006; Herdt, 2019)?

Undoubtedly, Alexander von Humboldt is widely renown as a universal scholar and, in the course of his vast expeditions, did in fact study myriad matters of tangible reality – be it plants, animals, humans or the surface of the earth. Yet, a closer look at Humboldt's work reveals his (from a contemporary perspective) clearly natural scientific approach (von Humboldt 2014; Martin, 2018; Meinhardt, 2018; Wulf, 2015). His way of thinking became apparent even in his elaborations on and examinations of humans and social processes, which he would at times make subject to his scrutiny, albeit studying them in a very similar manner as he studied plants.

4 Starting Points for Interdisciplinary Research on Digitalization

This leads to a second decisive aspect of the major challenge that is posed by inter- and transdisciplinary research: the paradigmatic foundation of methods. Still unknown to Humboldt, today, a variety of methods and underlying paradigms from the humanities, cultural studies and social sciences constitute multiple disciplines' arsenal on appropriate strategies to gather new findings and insights. Here, finding shared approaches seems comparably easy – for example, bearing in mind the widespread use of quantitative and qualitative methods for data generation and processing. At a closer look, however, profoundly different traditions and styles of handling and interpreting such data emerge. While the bases of statistical analyses remain the same, the contexts in which such methods are employed as well as how their results are used and interpreted vary considerably across different lines of research.

Digital data, which likely provide the very foundation of research on digitalization, appear as a unique common ground, showing a clearly universalistic component. The term digital refers to data underlying a wide range of contemporary phenomena – be it, for example, communication, individual mobility or healthcare and medicine. Speaking of big data marks a conceptual effort to grasp this gigantic, seemingly infinite generation of data, which is continuously processed and analysed by globally operating technology and internet corporations and may itself constitute as well as be transferred to new, wholly digital spheres. While this is outlook is intriguing, in my opinion, focusing on this rather basic aspect distracts from the fact that data only gains meaning in interaction, as it is being looked upon and referred to. Put frankly, if we sent our rich data bodies to the moon, there, they would prove just as useful as the many rocks covering its surface. Thus, as has become a popular bon mot today, behind most data are people – and it is them who make data come to life, who render its interpretation worthwhile. Contemporary grand debates on data aside, research almost naturally – and often implicitly – presumes this coherency, as the data we analyse is, of course, not arbitrarily chosen, but needs to align with our research interest. Coming back once again to my already slightly overused own example, I might look at data on twitter usage of members of parliament. Political scientists such as myself may find the

frequency and timing of tweets interesting – as well as their content, which can be made subject to respective analyses. Consequently, two components of gathering empirical data in disciplinary research on digitalization can be differentiated: a) digital data which is generated by technical devices and b) information on their usage in a broader context of interest, which is determined by discipline. By now, the computer scientists among the readers probably figured the point I am trying to make, as they are familiar with user-centered-perspectives and the notion that an in-depth understanding of technologies' effects, its context-specific usage modes and interactions with individuals can only be attained by including the people behind the screens in the picture (Abras et al., 2004; Endsley, 2016; Garrett, 2010). Without a user, a computer is meaningless.

Both methodical approaches in digitalization research – looking at digital data generated by technical devices as well as user data generated by individuals – offer valuable starting points to further a foundation shared across multiple disciplines.

5 A Glance at the Past: On Technology and Responsibility

In the early 1990s – when I was still used to a commodore 64 and little by little becoming acquainted with newly invented Pentium processors, CRT monitors and eventually the first modem – a new line of research on "informatics and society" was formed in computer science, whose proponents dwelled on various (possible) effects of digitalization on society. Today, their elaborations appear as clear-sighted as unheard of, a silent revolution of which most parts of the public have not taken any notice at all. Decades later, in 2017, the German Internet Institute – also known as Weizenbaum Institute – was founded as a hub for research on interactions in sociotechnical systems. It was its eponym, Joseph Weizenbaum, who, as he introduced the speech processing software ELIZA in 1966, partly anticipated artificial intelligence and chatbots and already sought to veil human-machine interaction. Behind this idea stands the turing test, aimed to uncover such simulations. Today, as I enter a modern car, after casually greeting it with "hey, car", I may inform said automobile on my music preferences, ask to regulate the temperature – and get a sensible response. Nowadays, artificial intelligence is everywhere and the turing test has, so to speak, overrun itself – although it has not lost any of its significance and is still applied today (e.g. to identify spam e-mail). As much as we know about Alan Turing and Joseph Weizenbaum, both were – at least at times and for a variety of reasons – not happy people. Also, they have both reflected profoundly on their work and its relevance (which, among pioneers of computer science, appears to be a fairly common phenomenon). Turing engaged in dispute with the philosopher Ludwig Wittgenstein on the significance of mathematics (which Wittgenstein deemed overrated) (Casti, 1998; Floyd, 2015; Floyd & Bokulich, 2017; South & Engels, 2018), while Weizenbaum referred to himself as a heretic. A look at his work reveals his primary objective: to link insight with responsibility and reason (Hartkemeyer & Weizenbaum, 1999; Weizenbaum, 2008; Weizenbaum & Rennert, 2008; Weizenbaum & Wendt, 2015). He was by far not the only one engaging in what I suggest to call critical computer science, with some of his colleagues being members of the German non-profit association Forum InformatikerInnen für Frieden und gesellschaftliche Verantwortung (computer scientists for peace and social responsibility). Today, most scholars agree that responsibility and reason are essential to digitalization. The fundamental question which underlies Weizenbaum's critical elaborations is whether we can or should promote technological progress without taking responsibility for its potential effects – which essentially brings us back to issues already dwelled upon by Turing and Wittgenstein. When Hiroshima and Nagasaki were devastated by the end of World War II, nuclear physicists around Albert Einstein and Robert Oppenheimer recognized their ground-breaking work had laid the foundations for weapons as fatal as atomic and hydrogen bombs. Since at least then it is obvious that technology is never a neutral thing of its own, but always subject to modes of utilization and contested

ascriptions of meaning. Once invented, controlling even early-stage technology's effects can prove utterly impossible (Banco, 2016; Monk, 2012; Oppenheimer, 1955). To be honest, when I think of my very own, early 1990s experiences with digital spheres, at times I feel we might have again become overwhelmed by technology – similar to Goethe's famous Zauberlehrling (sorcerer's apprentice), who, after summoning a respectable number of ghosts, eventually found himself unable to get rid of them. We live in smart cities and in the age of the internet of things, develop highly complex virtual spheres, e.g. with the aid of augmented reality, employ diversified sensor technologies to re-assess and ever so precisely measure every inch of the physical world, promote artificial intelligence and autonomous systems as to render them increasingly independent of human input. When I was a teenager, the holodeck on starship enterprise seemed as fascinating as unattainable. Today, we appear to have gotten unlikely close to let that famous fictional simulator become reality. Is this, however, a cause for concern?

6 Ubiquitous and contested: Digitalization today

Contrary to Weizenbaum's apprehensions, nowadays, addressing societal challenges posed by digitalization is deemed crucial by many. Additionally, critical reflection on digital technology's impact on society is encouraged by its growing ubiquity. Personally, as a social scientist interested in technology, I find witnessing these developments intriguing. Considering the history of technology in modern societies, a certain pattern can be distinguished: First, the introduction of a new technological accomplishment is met with euphoria and scepticism alike (just think of the first, still rather explosive steam engines that gave the Industrial Revolution momentum or Bertha Benz's early roaring automobiles). After a phase of trials, learning and user-oriented modifications, eventually a complex, well-controlled and highly regulated socio-technical system emerges, which reduces risks and dangers to a minimum and thereby renders the respective technology utilizable for many. Nevertheless, every technology implies its drawbacks, although we tend to forget about them: while cars constitute almost integral elements of contemporary inhabited spaces and landscapes, they still pose a danger to human health and lives on every single day they are used.

With digitalization progressing quickly, this dialectic relationship between technology and society increasingly becomes a focus of public debate. As we witness the amalgamation of the real world and digital spheres, we recognize how the latter continues to gain relevance. Asking how far the digital world influences the real one is a question of utmost topicality. Numerous fictional dystopias are based on the idea of technology and machines taking control. Current progress in research on artificial intelligence gives way to extensive elaborations on its possible detrimental effects, with renown intellectuals such as Margaret Boden, Marvin Minsky, Melanie Mitchell, Stuart Russell and Toby Walsh engaging in lively debates (Boden, 2016; Minsky, 2006; Mitchell, 2019; Russell & Norvig, 2009; Walsh, 2018), which are additionally fired by highly controversial statements such as made by Google, therein proclaiming the dawn of a new age of super-advanced digital technology (Kurzweil, 2012).

7 Online Communication at a Crossroads

Due to recent events, in our everyday work at university, we are once again reminded how crucial social interactions and personal communication are. Of course, this can be (and is increasingly) done online, as we met virtually for this conference. However, with the current circumstances forcing us to rely almost exclusively on digital communication, its limits and shortcomings become all too clear. As valuable as online courses prove to be in these times, many colleagues will agree with me that they cannot replace actual human interaction or the atmosphere and learning environment of a traditionally taught seminar. While we will surely come out of this pandemic with a number of insights to enrich

post-corona academic life, maintaining a shift so radical as the one we experience right now will most likely not be deemed desirable by many. A world in which digital spheres outweigh real-life experiences is barely imaginable – perhaps because their immediateness and tangibility, stimulating all senses, is so hard to replace. After all, are digital spheres no more than back-up resources, merely elaborated transmitters to complement offline living?

In 2020, it is perfectly obvious that digitalization has permeated various domains of everyday life and society. Still, after gaining a brief impression on what living in a more thoroughly digitalized society might look like, we would prefer not to. Probably, due to lack of genuine human interaction, a such society would feel somewhat clinical and deficient. The aforementioned Margaret Boden assumes that technology will never be able to completely replace human beings. Accordingly, an entirely digitalized society remains a vision of technology corporations (Boden, 2016). If Joseph Weizenbaum were to learn about her assessment, he might acclaim "Thank god!". Yet, digital spheres exert considerable influence on the physical world and social interaction, as we witness, for example, through smartphones' effects on face-to-face communication (e.g. division of attention between the people one is surrounded with and one's phone).

8 A Life online is imaginable, but not desirable

Communication has emerged as a particularly contentious issue in public debate. At this point, please endure my last reference to my well-exploited example as I come back to the parliament which, formerly characterized by the physical presence of its members, might see its very core (as being a place of gathering for political debate) eroded by concepts of liquid democracy. Such ideas were argued for by the Piratenpartei, which held considerable popularity in Germany a few years ago. However, to date, while said party has largely dissolved, the parliament remains a time-honoured institution of German democracy. Digital modes of participation diffuse, albeit rather reluctantly. In times of increasing digitalization, democracy faces a number of profound issues: who is participating in online debates? How does the culture of debate differ from non-digitalized discourse modes in public spheres? Probably, we agree that a president communicating mainly via twitter, insulting comments below online news articles, set-up Instagram stories and shitstorms do not constitute an optimal basis for fruitful democratic discourse. Indeed, such outcomes have become a popular study subject, so far adding to the impression of online-based debates being rather emotional, frivolous and short-sighted, while traditional, offline modes of dispute warrant more rational, reliable and balanced exchange. Whether this differentiation holds true in the long term remains to be seen. Bernhard Pörksen, a researcher mostly engaged in media studies, compares the degree of our ability to communicate beneficially online to toddlers only just learning how to speak. Consequently, we are merely at the beginning of learning digital manners and still await major parts of our online socialisation (Pörksen & Schulz von Thun, 2020). Perhaps digital spheres will forever appear as artificial spaces, although today, an incremental hybridisation of the online and the real world seems far more likely.

9 The Future of Scientific Collaboration

Returning to our initial question, to promote inter- and transdisciplinary collaboration, I argue for the broader diffusion of contemporary models for the study of micro-spaces: topic-centred research labs (Bergvall-Kåreborn & Ståhlbröst, 2009; Dell'Era & Landoni, 2014; Filho, 2019; van Joolingen, 2005; Keyson, 2016; Marvin, 2018; Pallot, 2010; Ståhlbröst, 2008). In my opinion, such spaces of manageable size provide excellent opportunities for interdisciplinary analyses of intersections and linkages between contemporary meta-developments and grand challenges such as climate change, migration and health in

an increasingly digitalized world. In the future, I hope to see more exchange between scientific domains to encourage more integrated thinking, particularly on issues that a) can only be understood by reconciling multiple perspectives and b) eventually affect us all (such as threats posed by climate change and global pandemics). For example, the overall concept of a sustainable, digitalized society paradigmatically aims to incorporate multiple claims, interests and issues (Bradley, 2007; Hazas, 2018; Osburg & Lohrmann, 2017).

Do we need a shared language to promote interdisciplinary collaboration? Perhaps, such a common foundation can emerge in a bottom-up manner, as studies are conducted and received across various research domains. Such exchange, naturally, requires compatibility and mutual understanding, but certainly not (as is sometimes argued) surrendering disciplines' conceptual, methodical and empirical bodies of knowledge. Indeed, building a respectful co-existence between methods and theoretical approaches instead of preserving dissent and competition seems both overdue and more fit to bear comprehensive insights. In retrospect, the conditions to strengthen interdisciplinary exchange and mutual acknowledgement look particularly favourable today, as several rapprochements have already been initiated. Furthermore, adhering to ethical standards for research such as the inclusion of various perspectives, cooperation, participation and allowing for diversity of arguments, theories, methods and scholars alike contributes to the success of forward-looking interdisciplinary exchange (AI-Youbi, 2020; Fitzpatrick, 2019; Mitchell, 2017; Ranson, 2018; Schuelka, 2019).

To this end, modern universities should offer multiple arenas and opportunities for dialogue and collaboration, so that researchers from diverse disciplinary backgrounds can, as suggested by the conference title, actually get together (Alexander, 2020; Aoun, 2017; III, 2019; Kerrey, 2017; Staley, 2019) and build strong academic communities to come up with robust, sensible and comprehensive insights as basis for a future both digital and analogue.

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Part A: Perspectives on Digital Health

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Digital Technology in Health Education? – Opportunities for New Mothers in Mexican Public Healthcare Services

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Abstract. The Mexican healthcare system deals with several challenges such as a high level of fragmentation, low investments by the state and remaining high out-of-pocket payments. The socioeconomic status of each family decides which access to healthcare is granted due to the form of health insurance provided. Health literacy rates depend highly on the educational level, correlate with health inequalities and influence health-related decisions such as breastfeeding strongly. This study presents first findings of problem-centered interviews (N=9) from a case-study in Guadalajara, Mexico. It shows a possible starting point to integrate the usage of digital devices in the Mexican public health sector to interact with new mothers who are hospitalized after having given birth. Findings suggest that the use of digital technology could help to raise the health literacy in the specific decision of breastfeeding.

Keywords: Breastfeeding, Healthcare, Inequality, Mexico, Technology

1 Introduction

Many countries have initiated attempts to reduce health inequalities. Improving health equity requires extensive collaboration between health and other sectors using evidence arising from new and innovative research strategies (Beckfield et al. 2015). Inequalities in healthcare have been analyzed and researched on several levels and in different country settings (Atun et al., 2015). The powerful role of health literacy as a concept to enable patients to better understand their health condition and make respective decisions with less uncertainty has been discussed extensively and with diverse perspectives since almost 50 years (Simonds, 1974). Not only has its importance been highlighted, but it is considered a global strategy. I Its goal has been to focus on the individual patients and the level of information they receive (Juvinyá-Canal et al., 2018). The interdependence of health inequalities and health literacy is underlined by the consensus of the European Consortium on Literacy for Health which defines the knowledge of relation, abilities and the opportunity of understanding and applying information related to individual health (Sørensen et al. 2012). People's literacy

level affects their ability to access health information, to learn about pre-care and health promotion, to follow treatments and communicate about health issues with others, and take decisions on a daily basis (Doson et al., 2015, Juvinyá-Canal et al., 2018). Moreover, there is a strong correlation between literacy and health self-assessment, and literacy has a specific, direct and independent effect on the assessment of health (Juvinyá-Canal et al., 2018).

1.1 Motivation

Despite these positive effects of health education for patients, health services globally struggle when it comes to professionally trained personnel, who can provide adequate care levels and fulfill the demand for a rising level of information. We argue that a digitalized education may serve as an alternative way to raise the level of individual health literacy of new mothers with a possible consequence of a direct impact of the children's health (Juvinyà-Canal et al., 2018).

1.2 Relevance

In Mexico, in a health system where prevention, pre-conception care and prenatal control are vulnerable, it is complicated for mothers to prepare for the arrival of their children, both physically and by informing themselves about pregnancy and breastfeeding (Gonzalez de Cosio, 2016). Especially, if they are not women with previous pregnancies their experience is only empirical, and transmitted by previous generations of other women in their family group and acquaintances. The influence of (older) family members is relevant for the transmission of cultural beliefs and nutrition habits between generations (Cosío-Martínez et al., 2017). The Mexican case study therefore presents an interesting case as there is a wide fragmentation and diversification within the system itself.

1.3 Aim of this contribution

This research first works out the advantages of increased health literacy for the decision process, then analyzes the Mexican health care system and answers the question of why it can make sense to take supporting action with digital contents. Finally, it presents first results of a possible solution to deal with the problem of a lack of knowledge of new mothers in the decision taking process of breastfeeding.

Specifically we ask: How could the specific knowledge of the benefits of breastfeeding be improved during hospitalization? How could the usage of digital technology be helpful in the context of the over-crowded public Mexican healthcare system? Which outcomes could be measured if minor digital tools are used by the medical staff right after giving birth or within the medical check-ups during a pregnancy?

2 Related work

One of the most important elements in the ability of a woman to engage in health promotion behaviors to protect their neonates and themselves is maternal health literacy. Cross-sectional studies have revealed that inadequate health literacy could be associated with adverse effects on health knowledge, preventive behaviors, use of preventive services, and the ability of mothers to care for their infants. (Khorasani et al., 2017).

Exclusive breastfeeding as part of this health education connects a variety of research fields. The knowledge and education about advantages of exclusive breastfeeding is connected to a certain level of education. Non-restricted access to such information is relevant for successful early-childhood health interventions. The role of the woman and the female image in a society is influencing the situation of a breastfeeding mother. In addition, there are several already researched outcomes of breastfeeding for children's health.

There are measurable variables such as weight gain of a newborn, vulnerability towards infections such as diarrhea, allergies and subjective, qualitative experiences of mothers e.g. bonding with newborn or a healthier lifestyle during the breastfeeding period (Perez-Escamilla et al., 2012). However, the process of

decision making for or against exclusive breastfeeding for the first 6 months of the newborns life is yet not-well examined. Those few studies existing show that in several societies exclusive breastfeeding for the first six months is no longer the norm (Colombara et al., 2015). Morover, the multifactorial determinants need support of several levels which include political guidelines, interventions to social norms and the role of the woman in a society (Swigart et al., 2017). Norms, values and the labor market play crucial roles in the complex context of a new mother to the decision of exclusive breastfeeding or not (cf. Perez-Escamilla et al., 2012, MICS Report, 2016).

It is therefore of due importance for policy-makers and the health system as a complex institution to gather information of women's decisions against exclusive breastfeeding (cf. Victora et al., 2016). After all, if relevant interventions are adequately undertaken and offered to the mothers, the percentage rates of breastfeeding mothers react quickly (Sinha et al., 2015). Sanchez Espino et al. (2019) used an educational intervention approach to improve direct skin-to-skin contact and early breastfeeding in a rural zone in Mexico. They underlined the power of a low-cost intervention which generated the direct skin-to-skin contact generated instead of an incubator as standardized practise. The medical and psychosocial importance of breastfeeding has been highlighted by interdisciplinary research. Nevertheless, the decision taking process has, to our best knowledge, not been researched so far.

We chose the Mexican healtcare system as object of investigation because it has two characteristics that are essential to the objectives of the study:

First, the topic of exclusive breastfeeding has to be researched in a specific country or region in the context that safe access to clean water or high standards of hygiene influence the preparation of milk supplements. This means the situation of developed countries has to be seen differently from the situation in developing or emerging countries (WHO, 1998). Exclusive breastfeeding is highly recommendable in least developed countries with low resources where a high mortality rate because of infectious diseases still exists (Fewtrell et al., 2011). Second, not only the Mexican healthcare system, but health services globally struggle when it comes to professionally trained personnel, their time for adequate care and the demand for more information of patients (Urquieta/Villareal, 2016). A digitalized education targeted to raise the individual health literacy of new mothers could in fact have a direct impact of the children's health (Juvinyà-Canal et al., 2018).

3 Theory

This chapter presents the theoretical background of this study as well as the institutional classification.

3.1 Health inequalities

Health inequalities begin to emerge during childhood and despite global improvements in infant and <5-year-olds' mortality rates in recent decades, significant inequalities in these rates exist within and between countries. Thus, socioeconomic inequalities generate health inequalities and vice versa (see Beckfield et al., 2015, Eikemo, 2008, Mackenbach 2012). Research has also indicated that social and economic factors embedded in societal structures are key drivers of these inequalities (Wilkinson et al., 1998).

The state is responsible to guarantee equity. In political terms, this means that every person is seen equally and has the same rights, independent of their socioeconomic status (Strünck, 2005). As example for political equality, the opportunity to access healthcare is a relevant example. Any deviation of these opportunities is counted as inequality in healthcare. Health inequality is a pressing societal and policy issue as it results in unnecessary premature deaths, entailing large economic costs in terms of lower productivity and higher healthcare costs (Hill, 2017, Mackenbach 2012). The Mexican healthcare system has developed strongly in terms of coverage rates. Although on paper equality and

service for all is guaranteed a closer look shows high rates of inequality in terms of rural areas, subgroups of the society as well as dependency on socioeconomic backgrounds (Urquieta/Villareal, 2016). Therefore the socioeconomic situation decides which type of healthcare is accessible and the inequality of health is a major decisive factor (Puig et al., 2009).

3.2 Health literacy

To counter those inequalities, researchers often promote the training of health literacy, whichis explained as the ability to understand health related information in written or oral from and being able to translate this information into action and decisions (Sørensen et al. 2012). The term roots from the clinical perspective and describes a critical risk factor (if not able to understand health related information) and from the public health sector when it comes to the personal asset of being able to transform the information e.g. into health related behaviour (Nutbeam, 2008). The public health' point of view is strongly related to ideas of socioeconomic and educational inequalites (Mackenbach, 2012) which, as stated above, lead to health inequalities overall. The relation between health literacy and health inequalities is a persistent one. Research shows that both theorized concepts, even if they range between the individual to a systemic or institutional level, are strongly connected to each other (Betterham et al., 2016, Volandes/Paasche-Orlow, 2007).

The relation between health literacy and any digitalized access to health is highly relevant to the successful usage of digital tools of all kind. All forms of digitalized usage of mobile and digital health information has become more important over the last decade. The used applications need to be applied to the potential consumer taking into consideration their level of health literacy (Kreps, 2017, Anstey Watkins et al., 2018).

3.3 Mexican Healthcare System

The Mexican healthcare system is broadly spoken devided into three different pillars.

The first is formed by the social security institutions which are led by the federal government and mostly financed by manditory employer, employee and government contributions. The services are free of charge for members in the clinics and centers run by the *Instituto Mexicano del Seguro Social* (IMSS), the Mexican social security institute. A smaller part of this string is designed for civil cervants (ISSSTE), the armed forces and workers in the biggest petrol fabric (PEMEX) (OECD, 2017).

The second pillar is organized mainly by the Ministry of Health (MoH) which is responsible for the population who is not in formal employment situations. Each health insurance covers different health services and guarantees access to distinguished health centers, diagnostical tools and the type of hospital (Puig et al., 2009). In Mexico a 3.6% equivalent to 2.1 million people do not count with formal employment and regular salaries according to a report by the National Institute of Statistics and Geography (INEGI, 2015). The social health insurance program which was in place during this study was called *Seguro Popular*. The ongoing reform renamed it now as *INSABI*. It is mainly financed by public funds and added up with modest user fees for affluent users.

The insurance program "*Seguro Popular*", which was still in place during this research, was created as a public policy that sought, through public health insurance, to provide financial protection to the population that lacks social security, ensuring thus their access to health services. This program was intended, among other things, to strengthen the actions involved with mother and child health and to implement a system to prevent complications before, during and after pregnancy, for mother and child (Mexican Government, 2018).

The third pillar represents the private health sector which is highly unregulated but plays a

significant role in the Mexican healthcare system. The respective quality, prices and accessibility vary. However, these services are often used to avoid waiting periods, receive test results more quickly and enjoy direct contact to a practioner. Most private services are financed directly out-of-pocket. The invention of *Seguro Popular* has strongly minimized the out-of-pocket payments (OECD, 2017) but there is still work to be done as it covers about 41% of overall health spending per household, which is the second highest in the OECD comparison (OECD, 2017).

Consequently, we therefore argue that the Mexican healthcare system struggles because of overstrain, lack of time for medical staff to explain the benefits of breastfeeding and institutional factors that mothers do not knot know sufficiently of the measurable advantages of breastfeeding. We therefore conducted an intervention study to investigate whether the provision of information about exclusive breastfeeding, available on a mobile device, has a positive effect on the health literacy of hospitalized mothers.

4 Data and Methods

This study uses the technique of problem-centered interviews (Witzel/Reiter, 2012). Within the semi-standardized interviews we utilized a deductively developed questionnaire which combined closed and open ad-hoc questions to compare results between interviees as well as gaining in-depth knowledge about the construct of breastfeeding in the Mexican health system.

Empirical data was collected in may 2019 in the “Hospital civil Dr. Juan I. Menchaca” in urban Guadalajara, Mexico. The interview guideline was designed to gain in-depth knowledge of the experiences mothers had when giving birth in different institutional settings within the health system in Mexico and additionally of their knowledge of breastfeeding (complete questionnaire upon request).

Mothers were interviewed while they or their children were hospitalized. All mothers gave oral consent to use their data trustworthily and in an anonymized way. In total we interviewed nine mothers in this hospital. All of them stopped working because of the pregnancy or do not work in general which excluded work as a main opportunity cost to stop breastfeeding.

If mothers had never heard of breastfeeding or could not provide any information about that topic and its positive consequences, we conducted a direct intervention by the use of digital media technology. This utilized intervention needed low digital capacity from the participants, as this knowledge might always be a limiting factor when using digital technologies (cf. Deiters et al. 2018).

Participants watched videos on 1) the topic of breastfeeding in general, 2) breastfeeding techniques and 3) advice on storing human milk. We used an IPad as a visual and auditory support, thus projecting bed by bed and contributing to the information through digitalization.

The videos were obtained from the course of advisors in breastfeeding, which is provided by the foundation of Carlos Slim "Capacítate para el empleo" (Fundación Carlos Slim, 2019) and are easy to understand in all strata. In addition, the techniques and information provided at the end of the interviews about breastfeeding were taken from the manual of the "Advanced Course of Support to Breastfeeding" (CAALMA by its acronym in Spanish) (Vazquez-Reyes/Martinez Gonzalez, 2018).

After the intervention, mothers were asked if there was a difference in their perception of the topic, and if they believed that they were better informed than before, as well as if they understood what they were being informed about. They answered to be more positive and optimistic towards the topic knowing more techniques. Women felt encouraged to try exclusive breastfeeding.

In addition, we encouraged them to continue watching videos, join breastfeeding groups in social networks and use media such as Facebook®, youtube®, etc., with previous medical guidance to continue updating on this issue that has a significant social, economic, and health impact, which is a reflection of the quality of life of an entire country.

5 Analysis

Women in our sample did not have a high socioeconomic status and most of them, although they had taken prenatal care during their pregnancy, did not have sufficient pre-conceptional knowledge. During the prenatal control, although they had been informed about lactation and the benefits that it can have in the short and long term to their newborns, few had knowledge of the subject of lactation in an exclusive way. Only one out of nine interviewees could explain what exclusive breastfeeding means. Several participants stated that they supplemented the breastmilk with tea, water or formula milk (I2, I4, I5).

Although they had access to media, social networks, and the internet, most mothers in our study had not used the media for health education or had not received the benefits that digitalization can offer. As a result, most mothers were unaware of the enormous variety of benefits of breast milk. None of them were hardly able to mention at least one benefit like the reduced economic cost, the lower need of material such as baby bottles and their desinfection and lower probability of diseases for their babies (I2, I3, I5, I8).

Moreover, the different techniques of breastfeeding, the techniques of expressing and storing milk, the nutrients it contains, the length of breastfeeding and more specific issues were never mentioned. In addition myths and cultural influences are strong when it comes to exclusive breastfeeding. One interviewee (I2) explained "neighbours told me that I should not breastfeed my child as I was getting angry and was fighting a lot with my husband. They told me I will transmit all my anger to the baby through my milk"[1].

After intervention, however, participants stated that they will now intend to practice exclusive breastfeeding to the best of their ability. Mothers gained knowledge, myths and false information were clarified.

6 Discussion

The experience with the participants who were informed by videos was satisfactory for the intervening medical staff, since we were able to highlight the importance of the information. The natural interview scenario as well as the professional environment without influences by family members generated an open space to discuss questions and the lack of information. We found evidence that the information shared had a positive impact on those mothers who received the guidance on an individual level. Thus, the usage of digital tools helped medical staff to improve the individual health literacy on one specific topic in an efficient amount of time.

Of course our study has limitations. In this preliminary study, due to the small sample size and the limited setting, we do not aim to generate representive outcomes. Other measurable tools and an outcome check to evaluate the results could help to confirm findings in the future. In addition, although all mothers stated after the intervention that they now want to engage more in exclusive breastfeeding than before, we cannot rule out that social desirability distorts our results. In addition, it was not possible to control the potential change in behaviour. Nevertheless, the study shows a potential technique to generate relevant improvement of health literacy for new mothers in developing countries using small digital technologies as supporting tools. Not only could this usage of digital tools help to minimize persistent health

[1] Translated from Spanish to English.

inequalities which are strongly related to individual health literacy. A generalized and standardized usage of these tools might even help to even improve the institutional conditions for all new mothers within the Mexican healthcare system.

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Methodological Implications of Research on Technology Use by Healthcare Professionals: A short Introduction to Multidimensional Scaling

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Abstract. Healthcare professionals currently face different challenges in an ongoing reconstruction of care. Digitization and the use of healthcare-related technologies promise both an improvement in quality of care and an increase of treatment efficacy. Especially telemedicine systems seem to be capable to overcome current spatial and temporal limitations of care. As telemedicine appears to be a non-uniform term describing a variety of technological characteristics, the explanatory power of entrenched models for technology use varies across different contexts of use. To explore important contextual factors in the field of healthcare technology research and to enrich the methodological diversity in Information Systems research, this paper provides a short introduction to Multidimensional Scaling. Being able to visualize underlying dimensions of subjective perceptions, Multidimensional Scaling shows complementary applicability and use with regard to elaborated methods and a high integrability into holistic research strategies.

Keywords: Information and Communication Technologies (ICT), Telemedicine, Multidimensional Scaling, Phenomenology, Healthcare

1 Introduction

Information and Communication Technologies (ICT) are recently discussed in their function of highly potent accelerators and catalysts for digitization processes in healthcare (Krick et al., 2019). In its basic function to enable and extend interaction between persons and organizations, ICT promises to address different challenges present in many healthcare systems all over the world. While demographic change and the increase of multi-morbidity among elderly patients (Svensson, 2019) result in a need for coordination of interdisciplinary and intersectoral care, simultaneously an agglomeration of healthcare professionals in urban areas complicates an equitable delivery of care (Wilson et al., 2009). Meanwhile, Primary Care Physicians (PCP) serve as important coordinators in healthcare systems, as they regulate access to general and specialized (medical) care (Bashshur et al., 2016). Therefore, PCPs and their use behavior concerning healthcare-related technologies are of special interest. In the ongoing debate about ICT and its potential to improve quality of care, the use of telemedicine systems in primary care becomes a prominent issue, as telemedicine

systems might be able to overcome spatial and temporal limitations (Bashshur et al., 2016). From this objective, the necessity arises to define theoretical and methodological foundations of research. Primary care consists of many dissimilar facets due to a high variety of medical cases and treatments, while the concept of telemedicine comprises different technological settings (e.g. messaging, medical advice via telephone, audiovisual appointments, etc.). Therefore, generalizing, deductive research methods focusing on user acceptance show some limitations that might be encountered by increasing the methodical variety of research. In this context, a method is needed that is able to explore subjective latent dimensions of technology use, but simultaneously provides the possibility to deduce intersubjective results integrable into structural models. This paper addresses this issue by proposing Multidimensional Scaling as a complementary method and provides legitimation of theoretical considerations.

2 Theoretical Background

Telemedicine appears to be feasible to address current issues concerning different challenges of healthcare systems, as it "provides a virtual environment that enables remote interaction between healthcare professionals and their patients, and among healthcare professionals themselves" (Flumignan et al., 2019, p. 184). From this broad definition, different aspects concerning the concept of telemedicine arise: (1) There are different kinds of technology associated with telemedicine. "Virtual environment" might refer to telephone consultation (Baumeister et al., 2014), a combination of telephone advice and text messaging (van den Berg et al., 2015), an audiovisual appointment between physician and patient (McConnochie, 2019), or other forms of virtual interaction. (2) Telemedicine can be applied to different persons and different numbers of persons. Aside from a direct connection between physician and patient (Reed et al., 2019), other healthcare professionals might as well use telemedicine to connect with patients or other healthcare professionals (Marcolino et al., 2013). (3) Different patients or groups of patients can be addressed through the use of telemedicine systems. While some studies focus on heterogeneous groups of patients in primary care, e.g., patients with non-specific chronic diseases associated with a single PCP's practice (Orozco-Beltran et al., 2017), others report the use of telemedicine for very specific diagnostic procedures, but for a whole population of patients (Stanimirovic et al., 2020). These aspects show that studies investigating factors constituting user acceptance of telemedicine systems are not easy to compare. The explanatory power of generalizing models to explain user acceptance, e.g., the Technology Acceptance Model (TAM) (Davis, 1989), therefore varies strongly across different contexts of telemedicine use by healthcare professionals (R^2 varies from 0.161 to 0.78 in a review of different theoretical models predicting end user acceptance by Harst et al. (2019)). Thereby, uncertainty about an actual positive effect on patient related outcomes might even intensify the prediction of user acceptance amongst healthcare professionals. Designated the highest standard for systematic reviews in evidence-based healthcare, the Cochrane Library lists twelve different reviews directly addressing issues of telemedicine and its general usefulness in different medical disciplines. In summary, the majority of these reviews leads to the impression that sufficient evidence for an actual positive effect on patient outcomes is currently not given (Flumignan et al., 2019).

Taking into account these current issues in research on telemedicine systems and user acceptance of healthcare professionals as well as considering the importance of theoretical contextualization to improve description, explanation, and prediction of relevant phenomena (Hong et al., 2014), one might ask for a theoretical approach to formulate methodological implications that are able to

enrich the current set of methods used for research. Phenomenology appears to be an evolving approach in healthcare research to explore context-specific facets of phenomena (Carel, 2011), while being considered relevant for explaining healthcare professionals' use of digital technologies (Müller et al., 2020). Generally speaking, a phenomenological approach focuses on subjective human experience, e.g., using a telemedicine system to advice patients in a critical situation related to their chronical disease. To understand a phenomenon completely, such an approach asks to explore contextual (subjective) facets of the phenomenon and, by comparing it with similar experiences, extract the essence of it (Husserl, 2019). Such essential factors might then be integrated into generalizing (existent) models to be tested deductively. Introna and Ilharco (2004) demonstrate such a phenomenological *reduction* on the example of screens. While different research methods can be integrated into a phenomenological approach, in the context of user acceptance concerning telemedicine systems primarily explorative and inductive methods seem to be of interest. Following Carel (2011) on her assumption that human experience is based on perception, Multidimensional Scaling (MDS) offers an interesting statistical approach as it is capable to visualize individual perceptions on a specific objective and therefore makes it more accessible to analysis. Originating from psychology, an introduction of MDS in the context of technological use by healthcare professionals within Information Systems (IS) research is missing to date. The following section provides an overview of MDS and illustrates its value for this research field of IS exemplarily.

3 Methodological Implications

To understand contextual factors determining the use of telemedicine systems by therapists and patients, it is of great interest to explore their perception on relevance of a specific technology for their professional activity. Following a phenomenological perspective on human experience and its perceptual foundation, one possible way to explore the meaning of relevant technologies for therapists or patients is to analyze (dis)similarities of an individual's ideas about telemedicine (Introna & Ilharco, 2004). Therefore, one is able to recreate a therapist's or a patient's understanding of a 'useful' technology. One method that is capable of visualizing (dis)similarity data is called Multidimensional Scaling. In general, through using MDS one is able to arrange objects in a one- or multidimensional space with regard to their (dis)similarity. The configuration of objects, normally presented in two- or three-dimensional space, can then be interpreted through our visual senses, resulting in an intuitive way of analyzing even complex relations of objects (Borg & Groenen, 2010). In the following, a fundamental methodological introduction to MDS is presented. By comprehending the required statistical operations leading to an MDS configuration, the potential of this method to evaluate context specific aspects of technology use by healthcare professionals and patients unfolds.

An MDS configuration represents (dis)similarities of objects in an m-dimensional space ($m \in \mathbb{N}$). Therefore, it is the basis for an interpretation of underlying factors constituting (dis)similarities. The position of the included objects can be determined by different types of (dis)similarity data, i.e., correlations between objects or ordinal ratings of objects (i.a.). A typical method to collect data of ordinal ratings is to ask participants to compare sets of two different objects (e.g., technologies, countries, food), without specifying any underlying assumptions, on a Likert-scale (Borg & Groenen, 2010). In such a configuration, similar or highly correlated objects are close to each other, while dissimilar or weakly correlated objects are highly distanced (Borg et al., 2013; Borg & Groenen, 2010). To transform (dis)similarity data into distances within a visual representation, i.e., an MDS

configuration, different types of distance functions can be used. The two most commonly used distance functions are the *Euclidean Distance Function* and the *City Block Metric*, which are both specific versions of the *Minkowksi distances*. The following formula is used to calculate the distance $d_{ij}(\mathbf{X})$ between an object i and an object j within an MDS configuration **X** by effectively summing up the differences of i and j in every dimension $a = 1, \ldots, m$ and modelling values of $d_{ij}(\mathbf{X})$ through the parameter p:

$$d_{ij}(\mathbf{X}) = (\sum_{a=1}^{m} |x_{ia} - x_{ja}|^{p})^{\frac{1}{p}}$$

For p=1, the dimensional differences between two objects are summed up without actually modelling the resulting distance $d_{ij}(\mathbf{X})$. This kind of calculation corresponds the following visualization (Figure 1) of distance from one object A to another object B:

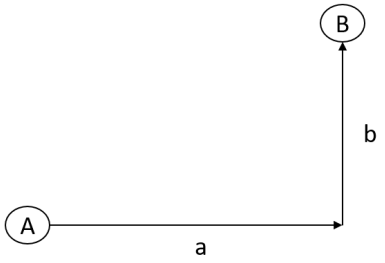

Figure 1. Calculation of distance within the City Block Metric.

The resulting distance is simply calculated through the addition of **a** and **b**. From its analogy to building structures of specific cities (e.g., New York) this kind of distance calculation is called *City Block Metric* (Borg & Groenen, 2010). In contrast, for calculating the Euclidean distance (p=2) between objects, dimensional distances are summed, squared, and finally their square root is taken. The following figure illustrates this kind of distance calculation:

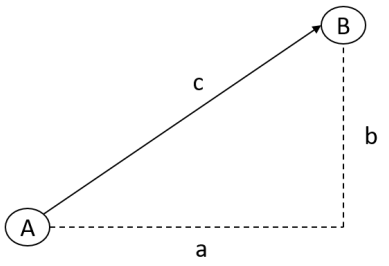

Figure 2. Calculation of distance within the Euclidean Distance Function.

The resulting distance between **A** and **B** in Figure 2 is **c**, calculated from **a** and **b**. MDS configurations are typically generated through an iterative process. Included objects are positioned in an m-dimensional space until their distances represent the objects' (dis)similarities as precisely as possible. For this step, different types of algorithms are used, e.g., *Torgerson scaling* or the *SMACOF procedure* (for more detailed information consider Borg et al. (2013, 81-86). To better interpret an MDS configuration, it is helpful to identify specific patterns of objects. Geometrical differentiations then need to be linked to content-related differentiations. In general, these content-related differentiations are based on heuristics, empirical and/or theoretical findings (Borg & Groenen, 2010). Figure 3 illustrates an example for an MDS configuration calculated with R (R Core Team, 2019) and the package *smacof* (Leeuw & Mair, 2009) using the *Euclidean Distance Function*. The configuration is based on data that results from pairwise ratings of healthcare-related technologies. Each data point represents an individual's comparison of two technologies on a 9-point Likert Scale (1-very similar to 9-very dissimilar). Overall, ten different technologies were rated (equal to 45 different ratings). For illustration in the context of this paper, data of the exemplary configuration was generated by the author's comparison of technologies that were discussed by PCPs and PCPs' assistants within a regional project about the digitization of home visits through tele-medical technologies. It is important to note that the assigned numbers on the dimensions of Figure 3 do not represent specific numerical values that can be assigned

to the objects (especially the zero points of the axes), but are only for orientation. As a possible interpretation for the distribution of the objects in Figure 3, dimension 1 might represent the intensity of physical contact between healthcare professional and patient. Objects on the left (i.e., Blood Coagulation Monitor [BCM], Blood Glucose Meter [BGM], and Blood Pressure Monitor [BPM]) appear to be associated with the most invasive interactions involving the patient. For measuring the blood coagulation and the blood glucose level of a patient, it is necessary to extract capillary blood, while the measurement of blood pressure requires direct contact to a patient repeatedly, especially while palpating the patient's pulse. In contrast, objects on the right (i.e., Digital Medical Visit [DMV], Smartphone [SP] and Electronic Health Record [EHR]) are associated with an interaction of the healthcare professional with a specific technology, e.g., documenting relevant patient-related information in an EHR, without having actually physical contact to a patient. For dimension 2, the degree of digitization appears to be a possible explanation. As venoscopes and infrared thermometers for ambulant care are currently designed mainly for analogous use, technologies like a tele-medical stethoscope or a mobile Electrocardiogram [ECG] are capable to transmit data via remote connections between physician and patient or physician and physician's assistant. Furthermore, the already mentioned objects on the left, associated with more invasive interactions between physician (or assistant) and patient, are currently combined with automated data storage and/or transmission and therefore can be thought of as technologies integrating digital functionality. Noteworthy, the interpretation of specific geometrical distributions of objects in an MDS configuration depends on a priori assumptions, hypotheses, or heuristics of the person interpreting it. To visualize an intersubjective understanding of a phenomenon, different individual ratings can be summarized into a single configuration by using specific algorithms. As a result, a common geometrical space for different subjective ratings can be generated, from which generalizable tendencies can be deduced (Carroll & Chang, 1970).

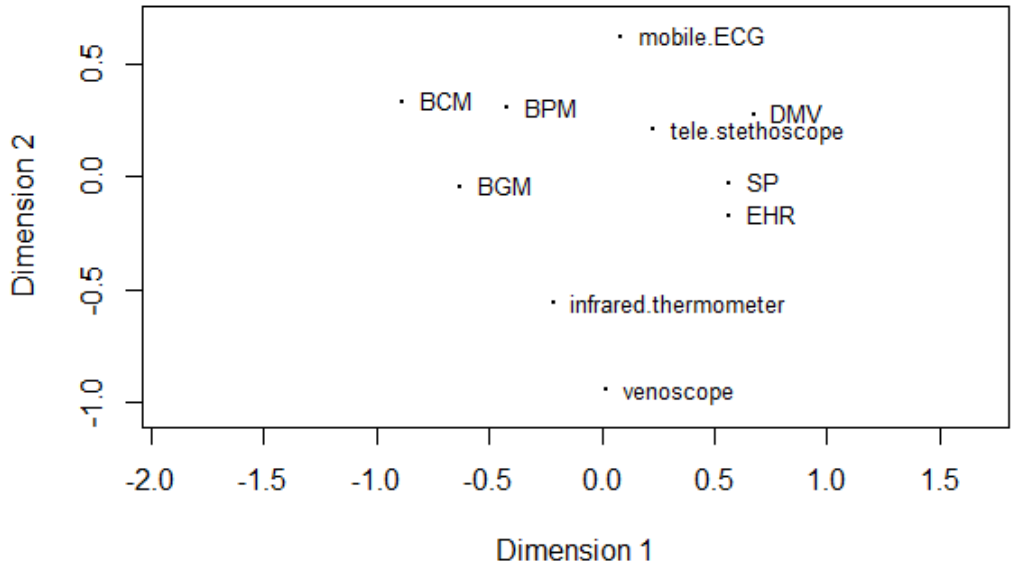

Figure 3. Exemplarily explorative MDS configuration for preference data

One possibility to visualize multiple individual perceptions on a set of objects (i.e., healthcare-related technologies in this context) is to use Unfolding Models, a type of Multidimensional Scaling that is based on hierarchical sorting. To evaluate the goodness of an MDS configuration, residuals are basically calculated through summing up the differences between configuration mapped distances and empirical (dis)similarity data. These residuals are then modified (e.g., through normalization) and transformed into different measures of fit, the so-called stress measures (Borg et al., 2013).

4 Discussion

In general, MDS can be used for both purposes to generate and to test hypotheses (Borg & Groenen, 2010). In its function to generate (or explore) hypotheses, MDS appears to be a suitable method to gain insights upon a research objective that needs to be further contextualized. Through the visualization of subjective and intersubjective perceptions regarding the (dis)similarity of specific objects, one is able to generate hypotheses, which can be tested deductively in the ongoing process of research. Although MDS is capable of illustrating subjective perceptions of a person or persons, qualitative interviews (especially semi-structured or open ones) normally generate more detailed insights. For a purely explorative approach, it might therefore be reasonable to conduct interviews before using preference data to select a group of analyzable objects for a later statistical analysis through MDS. Additionally, interviews conducted after explorative MDS might be very helpful to discuss the interpretation of an MDS configuration with participants, especially when it seems difficult to name dimensions of the configuration. While different qualitative interviews are not easy to compare because of their non-uniform structure, MDS configurations are calculated through a standardized process. By comparing different MDS configurations or integrating various individual configurations, intersubjective results can be generated.

Considering further inductive methods, explorative MDS and Exploratory Factor Analysis (EFA) both are utilized to find hidden structures in data. While explorative MDS is applied to find latent dimensions persons use for their judgements on specific objects or groups of objects (Borg & Groenen, 2010), the concept of EFA is based on the assumption that underlying factors account for relationships between specific variables (Kline, 1994). Although MDS configurations can be calculated through both subjective ratings and correlation of objects, EFA only uses the latter. As EFA is normally conducted with items based on psychometric assessments, one might argue that EFA requires a higher amount of a priori information than explorative MDS (for which subjective ratings are sufficient), but provides results that are easier to interpret. Analogically, confirmatory MDS and Confirmatory Factor Analysis (CFA) share a common requirement to formulate latent dimensions or factors to be tested, but differ in the extent to which such information has to be determined. As MDS and Factor Analysis therefore share a common understanding of latent dimensions constituting relationships between specific variables, MDS might also be utilized to inform structural models, which are key elements of Structural Equation Modeling (Little & Kline, 2016). Therefore, MDS can be considered valuable, especially through combination with other already entrenched methods in the field of IS research to enrich a methodological diversity (Venkatesh et al., 2013).

5 Conclusion

Following a phenomenological perspective on technology use by healthcare professionals, this paper introduces explorative MDS as a method to gain insights on contextual factors (or dimensions) constituting a wide range of explanatory power concerning generalizing models. While MDS is compared to other research methods in the field of IS, its comparability and integrability is demonstrated. As the scope of this paper and the illustration of

MDS is limited to its explorative approach, different issues have to be addressed by future research. Therefore, an analysis of hierarchical sorting data of PCPs and PCSs' assistants from an online survey by using Unfolding Models is considered a possible next step to demonstrate the practical application of MDS.

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Exploring Emerging Patient Responsibilities in Telemedicine Use: An Empirical Study

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Abstract. Telemedical solutions are increasingly utilized by physicians to cope with emerging challenges in modern healthcare. Rising numbers of patients due to demographic change and associated health issues complicate the comprehensive provision of care. Digital technologies, such as video consultation tools that establish a virtual connection between patients and practitioners, are able to antagonize these issues to some extent. However, the digitalization of care processes affects patients as well, who are increasingly obliged to be an active part of healthcare by using telemedicine and assessing its applicability and functionality. As a result, patients become more and more responsible for an effective and successful implementation of telemedicine. In that vein, this study proposes preliminary empirical findings and discussion points drawn from an ongoing research project. Findings suggest that responsibilities emerge regarding the preparation of online appointments, decision-making, the perpetuation of behavioral patterns, and the prevention of overuse.

Keywords: Telemedicine, Qualitative Study, Patient Responsibilities, Primary Care, Healthcare Technologies

1 Introduction and Background

The health domain faces great challenges that exert increasing pressure on existing structures and providers. For instance, the continuous demographic change and associated, age-related health issues are responsible for increasing patient numbers in need of care (Demiris & Hensel, 2008). Simultaneously, a decline in care availability and the emergence of an inequitable distribution of healthcare services takes place (Wilson et al., 2009), inter alia due to decreasing numbers of professionals, especially in rural areas (Mueller et al., 2020). As a reaction to these issues throughout the last two decades, an ongoing trend towards the digitalization of healthcare is noticeable. A variety of digital approaches and tools are under constant development and already in use. For instance, a wide spread technology in relation to others is the live video consultation (Kvedar et al., 2014). Further, sensory equipment can be used to measure vital signs of patients, which can be utilized by practitioners (Pantelopoulos & Bourbakis, 2010). Online databases and platforms allow patients to proactively seek information on health issues and treatments online (Ahmad et al., 2006). As a result, digital technologies promise benefits for effective and satisfying treatments, a comprehensive supply of care, an increase in availability and quality of

care services, and the release of provider-sided resources by making higher patient numbers more manageable.

Since treatments and therapies are mutual processes by nature (Hojat et al., 2010), involving healthcare consumers and providers as well, the introduction of digital tools and procedures increases the responsibility on both sides to cope with emerging necessities and challenges (Mueller et al., 2020). Digital technologies further promote deliberate treatments that can be triggered and partially controlled by patients as well (Castro et al., 2016). A shift from a more passive to a more active patient role can be detected (Osei-Frimpong et al., 2018). With the rise of digital technologies within therapeutic settings, patients are increasingly in charge to actively use modern tools, provide vital parameters and information, acquire the needed competencies for appropriate and effective use, and be aware of their own health and potential measures (Van Woerkum, 2003), hence increase their health literacy. Health literacy can be defined as "[…] *the ability to understand and interpret the meaning of health information in written, spoken or digital form*" (Adams et al., 2009, p. 144). The concept involves individual knowledge on both health and adequate treatment, as well as the required skills to plan and act appropriately (Nutbeam, 2008). It appears to be an important factor when it comes to adequately and comprehensively assess, understand, and communicate one's own condition (Kreps, 2017; Mueller et al., 2019), which can be reinforced by digital technologies (Kayser et al., 2015).

Digital technologies, as can be seen in many other sectors (e.g., Mäkinen, 2006), lower the threshold for partaking in dispersed processes. Hence, new habits and behavioral patterns are formed by patients regarding the consumption of care, the execution of therapeutic measures, and the consultation of physicians (Mueller et al., 2020). Simultaneously, patients become responsible for making decision and behaving in a way that aligns with the structures and processes prevalent in healthcare. For instance, overconsumption of digital offers can increase provider-sided workloads, whereas the neglection of those can render digitalization efforts unprofitable and cumbersome to implement and maintain.

This study seeks to expand our understanding of what kind of responsibilities emerge for patients playing an active role in digitalized care. To date, only little research has been done looking at the way patients can handle the increasing amount of telemedical offers in a responsible, beneficial, yet satisfying way. Hence, the objective of this research-in-progress paper, being part of a superordinate project, is to provide first empirical insights on the responsibilities of patients in telemedicine use. Hence, this study is guided by the following research question (RQ):

RQ: *What kind of patient responsibilities emerge from the incorporation of telemedicine tools within primary care treatment processes?*

The paper presents preliminary findings drawn from semi-structured interviews, which have been conducted engaging five users of telemedicine. The findings suggest several tasks, attitudes, and behaviors patients perceive and attach importance to regarding the use of a video consultation system. As a contribution, this paper further enables the implementation and utilization of telemedicine within primary care processes that incorporate the patient as an active, responsible, and self-aware actor.

2 Methods

2.1 Case Description

This paper is part of a larger research agenda within a regional project on the digitalization of rural primary care processes and treatments. The project is intended to strengthen the understanding of how patients and physicians perceive, evaluate, intend to use, and actually use telemedicine for primary care treatments. Amongst other approaches and innovations, the utilization of online video consultation tools is

treated as a feasible and beneficial measure to cope with increasing patient numbers and declining prevalence of healthcare professionals and graduates practicing in rural areas. As a prerequisite of digitally supported healthcare, the user acceptance of such technologies needs to be further elaborated. Here, this study positions itself in order to build an empirical baseline and achieve deeper insights on user attitudes and behavior.

2.2 Data Collection and Analysis

As a part of the overarching project, we conducted an initial set of five interviews engaging patients that have already encountered telemedicine in their treatments. The interviews took between 19 to 30 minutes (25 minutes on average) and were conducted by the author on a participating physician's practice site. Following a convenient sampling approach, the physician reached out to patients that have already used the video consultation system and were willing to participate in the study. The sample consisted of 1 female and 4 male participants aged between 35 and 52 years (42 years on average), whereof 3 showed non-chronic symptoms and 2 were patients with chronic diseases. They had used telemedicine between one and two times. The participants were briefed and signed an informed consent before each interview started, which clarified the data acquisition and analysis process, the voluntariness of partaking in the study, and their right to withdraw their participation. The interview guideline included questions on various factors underlying the use of and attitudes towards telemedicine. Here, the classification by Or and Karsh (2009) was adapted to our context, comprising patient, social, environmental, organisational, and technical factors. The guideline remained unchanged across all interviews. The interviews were audio recorded, transcribed non-verbatim, and translated from German into English for the purpose of analysis and reporting.

For preliminary data analysis in the light of the superordinate research question, we followed an approach comprising open, axial, and selective coding (Strauss & Corbin, 1998). While open coding seeks to assign labels to interview statements and passages, axial coding aims for subsuming labels under common categories. Finally, selective codes are identified that represent the major theoretical underpinnings of the data, containing and describing all axial codes. For instance, the interview statement "*In principle, I use it the same way as I did before, or rather in the same frequency, so I do not go to the doctor more or less often*." is openly coded as 'consultation of physician as usual', subsumed under the axial code 'moderate and conscious use', finally leading to 'behavioral patterns' as the selective code. In this preliminary stage, the data analysis used for this study is done by only one researcher. In upcoming studies, analyses are performed dyadicly to increase reliability and detect a broader spectrum of phenomena.

3 Interim Findings

The interim findings encompass four important categories that describe emerging patient responsibilities in telemedicine care, which are (1) preliminary considerations, (2) decision making, (3) behavioral patterns, and (4) overuse. As a supplementary finding, the benefits of telemedicine perceived by the participants are reported to describe positive reactions to using a video consultation tool. To preserve the interviewees' anonymity and prevent the delineation of interviews by their order, the numbers assigned to interviews have been randomized (Mueller & Heger, 2018).

3.1 Perceived Benefits

As literature and the collected empirical data show, the application of telemedicine such as video consultation tools within primary care processes and treatments come with meaningful benefits. In the perception of the study participants, the possibility to contact their general practitioner in a spatially independent way is of major value, being an efficient and pleasant way to get treatment:

> "*And in case of simple things, like discussing blood values, you only want to know how they are, are they okay* […] *I'm saving a lot of time, because I am not sitting here* [the practice]*, and for him* [the physician] *too, in that time he can do other things. I find it very effective*." (Interview 5)

> "*Consulting the doctor through the video consultation is simply easier for me because it is more pleasant, faster, I am more flexible* […] *Because otherwise you had to be here a quarter before your appointment, then you have three people ahead of you, then you wait half an hour. So you have an* [video consultation] *appointment at ten o'clock, it is finished in ten minutes and everyone is happy*." (Interview 3)

In addition, using telemedicine for physician consultation is oftentimes favored over visiting the practice personally due to, for instance, shorter waiting times or avoiding a potential contagion:

> "*It is also more comfortable to sit at home than in a waiting room, where many others with some kind of disease are waiting, because the risk of infection is not quite so high when you sit at home and wait*." (Interview 2)

> "*So if that was offered to me, I think I would always prefer the video consultation. Unless I really have physical complaints, or something visible where I would say, the doctor must have a look at it*." (Interview 2)

> "*I am here regularly and I didn't feel like always sitting in the waiting room, and then* [the video consultation] *was offered to me and I jumped on the offer relatively quickly*." (Interview 3)

Apparently, as our preliminary findings show, telemedicine can lead to high use intentions and actual use by patients that are seeking the aforementioned benefits and convenience. However, since digital offers such as video consultations lower the bar for contacting a general practitioner and ease the access to treatments, patients become increasingly obliged to think about the necessity, quantity, and extent of seizing the virtual alternatives. In this regard, the data suggests several patient responsibilities when it comes to actually using telemedicine for physician consultation.

3.2 Preliminary Considerations

One responsibility mentioned by the participants relates to considerations patients should engage in before consulting the physician via a digital tool or even making a respective appointment. In this regard, the interviews suggest that patients should carefully assess their health status, potential issues, and proper ways of dealing with them. Not every health issue is suited for telemedical treatment, since it requires, for instance, a physical meeting and examination. Here, the patient seems to become more and more responsible for the feasibility and, thus, the outcome of the consultation, obliging them to prepare each session by themselves:

> "[You do not] *address topics that you cannot actually discuss during the video consultation*. […] *you should bring along preparations, even as a patient, so that you do not address anything where the doctor tells you* '*well, let us end this here, because you still have to come by*'." (Interview 4).

Further, one participant mentioned that certain checks and assessments can be done independently and self-sufficiently:

> "*Before I drop by here* [the practice]*, I check a few things anyway. And if everything I checked is fine and I have not found a solution yet, then I will come here*." (Interview 2)

This, in turn, requires patients to have fairly high degrees of health literacy as well as self-efficacy when it comes to fathoming what treatment suits them best.

3.3 Decision Making

Being closely linked to the preliminary considerations, patients are invoked to sculpt their decision making process accordingly. Weighing off given possible treatments, including those supported by telemedicine, can lead to several outcomes that help the patients to behave in a certain way, hence making a decision. As the data suggests, the participants are inclined to waive using telemedicine in the first place given the situation:

> "*I would not even arrange such a video consultation appointment, but come here* [the practice] *directly for consultation*." (Interview 4)

> "*But in the future I must always distinguish between what I have and what I want, and then I can decide for myself whether to do it via video conference or in person. However, you have to think about it yourself* […]." (Interview 5)

One participant mentioned the need for judging the situation in an autonomous way and exhibiting a certain degree of self-discipline:

> "*I think that somewhat depends on the patient himself. How do I judge that myself? Do I have to go there* [the practice] *now? Is it serious? Of course, a certain self-discipline is necessary*." (Interview 5)

Apparently, the presence of telemedical offers calls for an increase in individual competencies that enable patients to make appropriate decisions without risking their health.

3.4 Behavioral Patterns

As some of the interviewees mentioned, the sole possibility to consult a physician online does not necessarily lead to new behavioral patterns regarding the frequency and reasoning of appointments. The data suggests, that although telemedicine facilitates easy and low threshold access to a desired treatment, patients tend to behave the same way as they did before:

> "*In principle, I use it the same way as I did before, or rather in the same frequency, so I do not go to the doctor more or less often*." (Interview 3)

> "*Actually, only when I really have an issue. Yes, sure, one should do preventive medical checkups, but actually* [I consult the doctor] *as usual in the end.*" (Interview 1)

> "*The question is how I deal with it myself. I handle it the way I have handled it so far, when I think I have to go to the doctor, due to a cold or whatever, I use this tool*." (Interview 5)

Patients behaving this way put less stress on physicians and the healthcare system overall. Thus, telemedicine is clearly seen as a valuable supplement and, in some cases, substitute for visiting the practice, as long as the patients' consumer behavior remains unchanged.

3.5 Overuse

However, while telemedicine lowers the threshold for physician consultation and, thus, consumption of health services, the risk of overuse emerges:

> "*Yes, if* [telemedicine] *is totally accepted* [by patients]*, it is like everywhere else, there could also be an overuse. But probably not by everyone, but this could of course also lead to it, because it makes it actually easier to contact* [the doctor]." (Interview 5)

> "*When everyone sees how easy it is to use, it can of course also go the other way around, that I use it more often, compared to when I go to the doctor*." (Interviewee 5)

As our data suggests, patients are aware of potential impacts that solutions such as video consultation systems can have on capacities of physicians. One interviewee refers to common sense when using telemedicine for treatments:

> "*I could imagine that this could be exploited. I could say, in case I need a yellow note* [attesting one's inability to work]*, due to partying a little bit more on the weekend than usual* […] *So if I am at the doctor's regularly and he knows me, he already*

knows how to deal with it. But as I said, I also know that you should not switch off your common sense. I know when I can get an online appointment and when not." (Interview 3)

It is also stated, that physicians might be able to detect unjustified online consultations, which takes away some portion of responsibility from the patient. However, patients tend to be aware of negative consequences the overuse of telemedicine might have, such as high effort for physicians to cope with increased availments.

4 Preliminary Discussion

The findings suggest, that patients do hold a share of responsibilities when it comes to making telemedicine work in healthcare. Apparently, patients are obliged to step into an active role and contribute to the success of digital tools such as the video consultation by adapting their use behavior. A shift from pure consumption to a form of co-creation can be detected (Osei-Frimpong et al., 2018). In order to achieve a satisfying and effective digital experience, patients increasingly need to be aware of their health issues, potential and feasible measures, and the applicability and bounds of technology. To further discuss the interim findings, two initial propositions are presented in the following. Propositions represent an entrenched way to depict theoretical outputs and infuse future research (Baxter & Jack, 2008). The first proposition covers the findings regarding preliminary considerations patients should encounter before making a telemedical appointment. With the rise of the video consultation being introduced by increasing numbers of primary care physicians, its feasibility and applicability to address the patient's health issue(s) should be incorporated into decision making processes:

> **Proposition 1**: In order to increase the effectiveness of telemedicine, patients should upfront assess the feasibility of using digital tools for treatment.

It becomes clear, that the patient's health literacy as well as self-efficacy regarding technology use and evaluation play important roles. Health literacy refers to an individual's knowledge about health, prevalent or emerging issues, and possible treatments, as well as the competence to process it and act accordingly (Adams et al., 2009; Nutbeam, 2008). Hence, as a prerequisite for an effective implementation and continous use of telemedicine, higher levels of individual health literacy must be achieved. Besides, once a patient is able to fathom necessities and possibilities of a digital treatment, the capability to use telemedicine properly is vital. Here, the concept of computer self-efficacy is important (Compeau & Higgins, 1995). Patients need to be able to use respective technologies in an effective and confident way. With regard to technology design, patients should be asked to provide information on their symptoms beforehand, while providing them informational support to accomplish this. The second proposition refers to the behavior patients should display in order to keep the amount of effort associated with operating telemedical solutions low and avoid overuse:

> **Proposition 2**: Patients should maintain behavioral patterns with regard to using telemedicine for physician consultation to prevent overuse and minimize efforts associated with its operation.

Deploying telemedicine within former analogous processes and operating it effectively comes with great efforts for physicians (Mueller et al., 2020). However, since tools such as the video consultation enable a low threshold and easy way to contact practitioners, patients might neglect those efforts since they take the technology for granted due to its high dissemination in other areas of life. A potential tendency towards a disproportionately frequented use emerges, which calls for a moderate, considerate, and goal-oriented use of telemedicine and associated levels of behavioral control (Ajzen & Madden, 1986). Respective behavioral patterns need to be formed and promoted in order to facilitate the digital

transformation of primary care procedures. On a design level of telemedical tools, the implementation of ways to assess the necessity of online treatment in relation to the amount of previous sessions and outcomes seems feasible.

5 Conclusion and Future Research

This paper proposes preliminary findings and propositions empirically drawn from an ongoing research agenda. With regard to the RQ, the findings suggest that a variety of patient responsibilities arise from the implementation of telemedicine within treatment processes, such as preparations and respective decisions patients should make upfront an appointment to ensure treatment effectiveness. The paper contributes to our understanding of the way patients perceive and use digital offers within care and opens up a wide space for further research. The paper exhibits some limitations, such as the small sample size and the low generalizability. For the time being, the study does not consider sample characteristics, such as varying health issues and technical skills, which might unveil new facets of the emergence and specification of patient responsibilities. A potential sample selection bias might remain undetected.

Thus, the paper calls for complementary research activities building upon the proposed findings. First, the conduct of additional interviews engaging a wider, more heterogeneous population can deliver deeper insights on patients' attitudes and behaviors while illuminating sample characteristics and differences. Second, subsequent studies should promote further development and extension of propositions that are suitable to be transferred into testable hypotheses, which then again represent the foundation for quantitative studies, e.g., in the form of online surveys. In doing so, generalizable insights can be achieved and further integrated within telemedicine design and application processes.

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Context Factors for Pro-social Practices in Health Care

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Abstract. In order to reduce the shortage of healthcare workers, researchers try to find ways to improve nurses' job conditions. A lot of effort concentrates on organizing shift work in a more agreeable way by providing more autonomy to the nurses, e.g., through self scheduling. However, increased autonomy also means that nurses have to resolve scheduling conflicts within the team. To that end, a good team coherence is essential. In this brief exploratory study we present the pro-social practices of three Japanese nurses, each one working in a different setting that brings specific opportunities for pro-sociality. The findings can serve as a starting point for more focused, context-specific studies on pro-sociality in outpatient, residential, or day care.

Keywords: Helping, Shift Work, Prosocial Behavior, Healthcare, Communication

1 Introduction

Countries worldwide face a shortage of nurses, a trend that is particularly pronounced in ageing societies such as Germany or Japan (Aluttis et al., 2014; Dumont & Zurn, 2007). One reason for this shortage are the strenuous working conditions in many healthcare institutions, leading to low job satisfaction and high turnover rates (Lu et al., 2019).

A major problem with working conditions is that critical healthcare services in hospitals and geriatric care often require nurses to work in shifts. This in turn entails several issues for health and well-being, including disturbed sleep patterns, reduced performance, psychological and physiological health disorders, and impaired social life (Costa, 2010; Fenwick, 2001; Perrucci et al., 2007).

However, while shift work in itself is problematic, some of the problems can be reduced through good and inclusive organization of the shift schedules (Nelson & Tarpey, 2010; Rönnberg & Larsson, 2010). This scheduling process is therefore an important part of work organization and when it comes to distributing popular shifts, it is often a source of conflict within a team. Each nurses has to reconcile private and work-related responsibilities and compete with the colleagues for specific free times, for example around traditional holidays.

In order to organize the shift distribution in a more human-centered (rather than "efficiency-oriented") way, digital technologies can play an important role. For instance, an interactive scheduling system we presented in an earlier study (Uhde et al., 2020) could increase nurses' autonomy and subjective fairness of the scheduling process. A fundamental design

rationale of that system was to give as much autonomy in planning to nurses as possible when needed, and automate decisions they consider less important. In case of a planning conflict, the nurses could resolve it within the team. However, for the conflict resolution to work well, a positive team spirit is essential. Thus, we integrated, pro-social shift planning practices, such as leaving a free shift to co-workers who need it more urgently, as the foundation for our interaction design (Laschke et al., 2020; Schlicker et al., 2020).

The above framework focused specifically on pro-social practices during shift planning to foster a positive team spirit. However, while shift planning lays the foundation for a functioning schedule, it only amounts to a small part of the nurses' work. Most of the time they are busy with activities relating to their care work, e.g., taking care of their patients. Considering the facilitating role of a positive team spirit on conflict resolution, we were interested in further pro-social practices of nurses that are not directly related to shift planning, but which may have an indirect facilitating effect by supporting overall team coherence. While this was our primary motivation to conduct the study, a positive team spirit naturally has several other benefits e.g., on job satisfaction, well-being, and the functioning of the company (Bolino & Grant, 2016; Gebauer et al., 2008).

There are several different healthcare contexts with specific shift models, modes of collaboration among nurses, and spatial distribution of the work. For instance, outpatient care differs from residential care. In order to get a better understanding of opportunities for pro-social practices in different healthcare settings, we conducted an exploratory interview study with nurses from different contexts. In the following sections we will briefly outline the interview settings and preliminary results.

2 Qualitative Field Study

2.1 Participants

We recruited three Japanese nurses (31, 31, and 32 years old; all female) in the Tokyo metropolitan area in July 2019 through a gatekeeper who works as a nurse herself. The participants had between seven and ten years of work experience as a nurse. We searched for participants with diverse work settings to allow for a contrasting analysis (see Table 1). The interviews took place in public cafeterias on different days in July 2019 and the bills were paid for the participants as compensation.

2.2 Procedure

We followed a guide with questions about the work setting, communication with co-workers, and pro-social practices (1) by the nurses themselves and (2) by their co-workers. This was followed by more specific inquiries about their feelings, thoughts, and behavioral responses to each of the practices. Moreover, we allowed for deviations from the interview guide to further inquire interesting topics. The setting in a public place was chosen to allow for a relaxed atmosphere. During all interviews the gatekeeper was present and we engaged in around 30 minutes of off-topic conversation before starting, further asserting a secure and comfortable atmosphere. Interviews lasted for around 30 minutes and were held and transcribed in Japanese.

	P1	P2	P3
context	outpatient care	residential care	day care
work times	shift work	shift work	no shifts
work place	flexible	constant	constant
role	regular nurse	ward leader	daily changing leadership

Table 1. Work context of the three nurses.

2.3 Analysis

We analyzed the interview transcripts following the Interpretative Phenomenological Analysis (IPA) methodology (Smith et al., 2009). Two independent coders (authors 1 and 2) listened to and read the interviews separately, noting interesting formulations, content, and expressed feelings. In the next step, the two coders gathered their results and established consensus about the central, contrasting themes which we present in the following section.

3 Results

3.1 Work settings

Based on our recruitment, the three participants had very diverse work settings. P1 worked in outpatient care and her company had a shift model. However, she personally refused to work anything but early shifts: "Well, I told my company: 'I don't want to work too late'. […] And not too early either. […] If it starts at 7am or so, I don't do it. 8:30…8:00… At the moment, the earliest I have is 8:20." [P1, 22:46]. Based on prior experience at a former employer, she had a very strong opinion on shift work: "The ones who want to work [at night], they say: 'I want some more money' or so. After 6pm the hourly wage goes a bit up. […] So there are some people who say 'I want to work some more at night', and they never object… there are some people who work like slaves. Like, they work early and then with no break they work the night as well" [P1; 23:58].

P2 was a ward leader in a small residential care company. She worked all shifts (night, early, afternoon). In contrast to P1, P2 prioritized a harmonious atmosphere over regular work hours and she had switched employers as well. However, in her case the reason had been that she was unhappy with the interpersonal communication at the prior work place, rather than work times.

Finally, P3 worked in day care, so her work place had more regular work times for all employees. There were two slightly different day shifts (7:30 to 4:30 and 8:00 to 5:00) and all co-workers were present during the day.

3.2 Communication patterns

P1 communicated with her colleagues very indirectly and mainly through a common work account in a messenger app. While she worked for the same clients and in the same home as some of her co-workers, she had never met most of them in person. Her communication was largely mediated by a central office of her company and she often didn't know who was on the other end of the line. In case of an urgent problem, she contacted the call center who then contacted her co-worker. In extreme cases, e.g., when there were uncertainties about the clients' medication intake, she would call a colleague on the phone – but this rarely happened. Less urgent information could be left for the co-workers in a notebook in the clients' homes, such as a reminder to switch the heater on or off.

P2 described the communication within the team as most essential and as the ward leader she felt responsible to assert an open atmosphere. In her ward, communication happened mostly directly, face-to-face, among those who were present. Otherwise she would also call or be called on the phone outside working hours, or use a messenger. Besides the shared work environment, her group had monthly drinking parties ("Nomikai") or other shared private activities: "So…we go drinking in our free time, we drink alcohol and have fun together. And if we get along well with the clients, they also join and we drink alcohol together or so. And we eat together with their families. We're like one big family" [P2; 6:10]. She has a close relationship with the other people at her work place, talking about both work and private topics.

P3 separated her work and private life more clearly than P2. In her day care institution, every day one team member was assigned the "leader" role and organized a brief stand up meeting in the morning based on previous notes and documentation. During this meeting, the daily leader informed the team about the clients who

were to come and they discussed the tasks of the day. Afterwards, everyone started to work and if necessary, documented notable information in a notebook that informed a later morning briefing. Given the day care setting, communication mainly happened within the standard working hours (7:30 to 5:00).

3.3 Pro-social practices

The three settings allowed for very different types of pro-social practices. P1 had almost no direct contact to her colleagues, but she described several pro-social practices mediated by traces on artifacts in the clients' homes. In the notebook, she wrote in large, readable letters, knowing that some of her colleagues were already old and couldn't see well. She exchanged smileys and stamps to signal sympathy in the messenger. Moreover, if she had time left after finishing her responsibilities, she cleaned the homes or the company car: "Well, I don't want to work there [if it's so dirty], so I clean it. If I clean it, the others feel better when they enter" [P1, 13:20]. She complained about other co-workers leaving places dirty, however. Once she had accidentally met one of them at the company building who happened to work with a common client. The client in question owned a parrot and she recalled that this topic gave room for a fun conversation with her colleague. Finally, she noticed that some other co-workers who were friends in private sometimes left alcohol as a present for each other in the fridge of the clients when they knew that their friend would have a shift in the same place later on. Although this was against the rules, she thought that the clients' families didn't mind.

For P2, prosocial activities consisted of their open, interpersonal communication. The team talked about both private and work problems, either face-to-face or on the phone and within or outside their shifts: "If something bothers them […] they are so kind to tell me quite openly" [P2; 20:02]. Generally the team coherence was good and they helped each other at work. An exceptionally high level of care for the colleagues was in a way part of the "job requirements".

P3 described that "non-leader" nurses were very busy during the day and had few chances to go out of their way in order to help others. Moreover, jobs were not clearly distributed among them: "The responsibilities and so on are not assigned […] if I find something that should be done, I have to do it." [P3; 21:14]. This left little space to show personally motivated, pro-social effort. The daily leader had more freedom and made sure that everything was going well. When she saw that someone needed help while she was the leader, she helped out – but saw this more as her responsibility rather than a pro-social effort. Additional opportunities to help were difficult to find, but she mentioned some smaller favors. For example, in the evening she made sure that certain material (whiteboard, pens) was already in place to facilitate a smooth morning briefing the next day.

4 Discussion

While this small sample can merely serve as a starting point for further research, we found a few interesting research directions and context factors to be aware of.

First, the nurses had very different priorities for their jobs. P1 had previously experienced flexible working conditions where she felt exploited to an extent. In her new job she stood up for her own well-being by demanding regular work times. Incidentally, she also had very little personal contact to her co-workers. In contrast, P2's close relationship to co-workers as well as clients made it acceptable for her to work in possibly unhealthy amounts and shift patterns. In comparison of the two cases, one advantage of P1's minimal social contact could be that it made it easier for her to stand in for her own needs to a greater extent, because she has less concern for her colleagues. This fundamental conflict between self-concern and other-concern should be taken into account for further research (see also Grant, 2016).

Second, although P1 worked alone most of the time, she had several object-mediated ways to communicate with her colleagues. This asynchronous but co-located form of communication (Kirschner et al., 2002) opens up an interesting design space for pro-social practices in outpatient care. While her personal relation to the co-workers was very limited, she mentioned some activities (writing in a friendly and understandable way, cleaning) that clearly had some pro-social motivation. Moreover, her co-workers used the common space to exchange gifts. Indirect, object-mediated pro-social activities are therefore a promising research direction for outpatient care.

Third, P3 worked in a relatively stable environment, but work responsibilities were not clearly distributed within the team. Each team member was responsible for all tasks that they may find. While this may be an efficient form of work organization, it also renders pro-social "extra miles" in favor of co-workers impossible to be recognized as such. For future studies of pro-social activites at work, this variable needs to be taken into account.

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Part B: Perspectives on Virtual Realities

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Combining the Virtual Reality with Biofeedback – State of Research in Nutrition

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Abstract. The digitalization of the health care system promises to improve care through the use of technologies that work with virtual reality (VR). In the field of nutrition research, various settings have taken place. But the research designs known so far were not supported by physiological values. Based on this gap and to structure current and future scientific work in this field I conduct a literature review. A selection of known biofeedback systems will be presented and checked whether they appear at all in the literature in connection with nutrition and VR. Results: The fact that only six papers have shown a sufficient relationship could be used to identify a deficiency. I conclude that VR-related technologies seem to be a promising approach that is worth theoretical and empirical research with increasing physiological parameters to improve nutritional behavior.

Keywords: Virtual Reality, Nutritional Behavior, Literature Review, Biofeedback and Physiological Parameter

1 Introduction

Haven't we all wondered whether we eat healthily? And even if you have a healthy diet, each of us has our cheat days. Be it at a birthday party, a big event, or a TV evening on the couch. We probably all reach too often for fast food, soft drinks, and sweeter than we realize. Especially in times of the corona crisis, when we stay at home as much as possible, I notice for myself that bad routines creep. The frequency of purchase reduced. Food that lasts longer ends up in the shopping trolleys and not necessarily the healthy alternatives. Hamster shopping for canned food, convenience food, and pasta is particularly prevalent in Germany but also all over the world. But even the delivery services are more popular than ever. Who doesn't like to order the pizza or pasta to the door during this time and hopes to support the local gastronomy financially. The incidence of nutrition-associated, non-communicable diseases such as cardiovascular diseases, diabetes mellitus type 2, and cancer is increasing worldwide. The dangers of a weight gain are particularly severe at the moment, as physical activities are limited. Both gyms and sports clubs are closed during the crisis. Psychological factors also play an essential role during this period. How can we arrange a regulated everyday life, which possibilities of employment are possible, how can we prevent possible anxiety states or even depression due to isolation but also maintain simple things like self-discipline and motivation for a healthy lifestyle?

In times of the Corona crisis, digital technologies are in demand as never before. Many different digital technologies are already used for the home office, for social life, and entertainment. Video conferencing is part of everyday working life. Why can't we use these technologies to improve other areas in life? For example, use innovative technologies to lose weight or watch our weight. TV formats such as The Biggest Loser have been using new techniques such as holography or modulable 3D graphics for years. They show candidates what you do to yourself and your body with the heavy overweight and what you could look like with ideal weight. In 2016, 39% of women and 39% of men aged 18 and over were overweight (WHO, 2017). But what about research. Are new technologies also being used here to address the global health problem of obesity?

This article examines a technology that promises both knowledge transfer and physical activity and has shown initial success in treating anxiety and motivational changes. But so far, it is not yet integrated into our daily life. We are talking about Virtual Reality (VR). Which researches are existing Virtual Reality in combination with nutrition and which biophysical parameters are recorded to show the influence on the body? Part of the papers is a literature review in which the VR technology has validated concerning behavioral changes or effects on physiological body properties. So the combination of VR on nutrition and biofeedback signals is scholarly in the literature databases of EBSCO, PubMed, WebofScience, and AIS and Google scholar. Six papers could be integrated into the study. These would be examined for the following factors,

- design
- biofeedback systems
- outcome-oriented
- construct
- effectiveness

The overall research question is included (RQ): Are physiological parameters recorded, using the virtual reality when it comes to diet-related motivation/therapy?

2 Theoretical Background

2.1 Virtual reality Technologie

VR applications place the user in a simulated, 3D environment. Head-mounted displays (HMDs) or VR glasses, such as Oculus Rift or HTC Vive, are used for this purpose, which shows videos and images in 3D format with an integrated screen (like a gym, or a mall). The image sections adapt to the eye and head movements of the user and, in combination with motion sensors, enable the exploration of 3D worlds. The additional use of controllers empowers the user to actively interact with objects in a virtual environment (Anthes et al., 2016). Possible applications for VR range from video games to traveling to places, education, and health applications.

Recent studies show that the concept of cognitive absorption plays a central role in the development of a learning process, such as a change in diet, through information technologies (Ehrsson et al., 2007; Reychav & Wu, 2015). The feeling of having a body in the VR environment (body ownership) is a fundamental aspect of self-confidence (Ehrsson et al., 2007). E.g., escape from your own obese body and adopt an ideal physique. The concepts of agency, i.e., the feeling of being voluntarily in control of one's actions, and body ownership, i.e., perceiving the virtual body as one's own (Slater & Sanchez-Vives, 2016). could be necessary for the nutritional sciences.

2.2 Virtual reality in nutrition

Virtual technologies are already part of current research in the healthcare sector. They are used in the treatment of anxiety disorders, stress, and pain management but also in nutritional behavior (e.g., obesity) (Riva et al., 2016). VR has recently been explored from different perspectives in the field of food consumption studies. For example, the aim of virtual

technologies in eating disorders is to analyze behavior and motivate people to choose the right food and reduce the desire to eat (Gutiérrez-Maldonado et al., 2016). The relationship between external eating habits and food cravings during exposure to VR environments has been investigated, showing that VR cues have been shown to alter emotional, cognitive, and behavioral responses (Ferrer-Garcia et al., 2015). VR technologies offer the advantage that the interaction with one's own body is carried out in the virtual environment and thus has a positive effect on immersion (immersion) (Slater & Sanchez-Vives, 2016). But to what extent is the possibility of immersion used in the field of nutritional science and dietetics. Or in the therapy of obese people and to what extent is this supported by physiological measurement methods.

2.3 Biofeedback

Any learning process that causes a physical reaction can be called biofeedback. For example, if you burn your tongue over a hot drink, you feel a pain that triggers a learning process. Biofeedback devices work similarly, only less painful. Different body functions can be recorded with systems (e.g., heart rate, muscle activity, brain activity) to show the physiological state, changes, and to document the clinical effects of therapy. It shows, for example, what influence the physical condition has on the recovery process (interaction of body and mind). Since there is optical feedback, these systems can also be used to influence bodily functions. Biofeedback systems can be used mainly in the area of stress, and a subsequently supervised meditation, but also in training and conscious tensing of different muscles. In the case of nutrition, the skin conductivity and stress level is decisive, as well as the need for an unhealthy diet, but also the different brain regions. Like emotionally, the different foods are connected to the test persons. (Haus et al., 2016; Lang & Lang, 2007)

Here is a short overview of my experience of different feedback systems which has led me to the topic:

- HRV Monitors: Measures pulse and heart rate variability, measurement on fingers, or earlobes. Often use in lactate test.
- Electrocardiogram (ECG): Measurement of heart rhythm mostly by sensors or chest straps.
- Electroencephalography (EEG): Measurement of brain activity by voltage changes on the head surface (hood). You can use EEG, for example, to burst a balloon by making a nail rotate with your thoughts.
- Electromyography (EMG): Measurement of muscle activity through action currents. The voltage between the two electrodes is measured. I have attached them to the upper and lower leg to measure the muscle contraction in different phases of standing up.
- Skin conductivity (SCR) Measurement of the electrical conductivity of the skin.

The measurement of skin conductivity, in particular, reflects the degree of psychological or physiological arousal triggered by cognition or emotions. The more sweat produced, the higher the current flow. And could play a more prominent role in the following papers.

3 Research Methode

I conducted a literature review of Virtual Reality Technologies (VR) research and practice in nutritional science, including biofeedback. The literature search and screening was done by the author only. A mapping review and a scoping review was used as a methodological foundation (Grant and Booth 2009). The databases on both the information society and medical research have been integrated to ensure that as many relevant articles as possible are reviewed. As the records in these databases (EBSCO, PubMed, AIS, and web of science) were small, an additional search in Google Scholar was performed. Here 1357 results were found, which were identified in a scoping review process to 51 relevant papers.

As the first database, the medical database PubMed was searched. In combination with the term Virtual Reality (VR) and Biofeedback system and conjunction with four essential measurements of the EEG of the EDA, the EMG and HVR 720 titles are found. Since for further research, the measurements in the field of nutrition are of particular interest and not the test for anxiety, sleep disorders, or balance or reactions, and the search was narrowed down in the second step. It would be further searched at PubMed with synonyms for nutrition (nutrition, food diet). Here are nine more articles displayed. These will be included in the further search. The same search query was made in EBSCO (2 hits) and I WebofScience (3 papers). In the AIS database, you can only find articles if you use the search terms in a limited way and make a combination of VR and biofeedback or nutrition. But there are also only two hits. Of the 16 articles found, 2 were duplicates. Due to the small number of hits, a search with biofeedback and virtual reality and nutrition were carried out at google Scholar. 2700 hits were found here. After reviewing the hits of the last ten years (from 2010), 1900 results remained. After excluding patents and quotations, 1410 results remain. By viewing the titles, 46 relevant titles were included, which are related to nutritional situations and biofeedback and VR after seeing the abstracts. Also excluded are items that do not include VR and do not have nutrition as a source or as Nutrition Science. Included are only papers, books, and journal articles in German and English language. Besides, titles that describe an overview of the points of interest after reviewing the abstract are included. Many items could already be excluded after viewing the title and the short description at google, so only 51 hits were taken further. After screening the abstracts, only 12 articles were included in the entire reading process because many reports did not stand the combination. In most cases, nutrition was only given as a source or as a condition or behavior of the research, or reality is a term for a temporal or local reference. After reading the paper, six papers were included in further analysis, which had a study design .

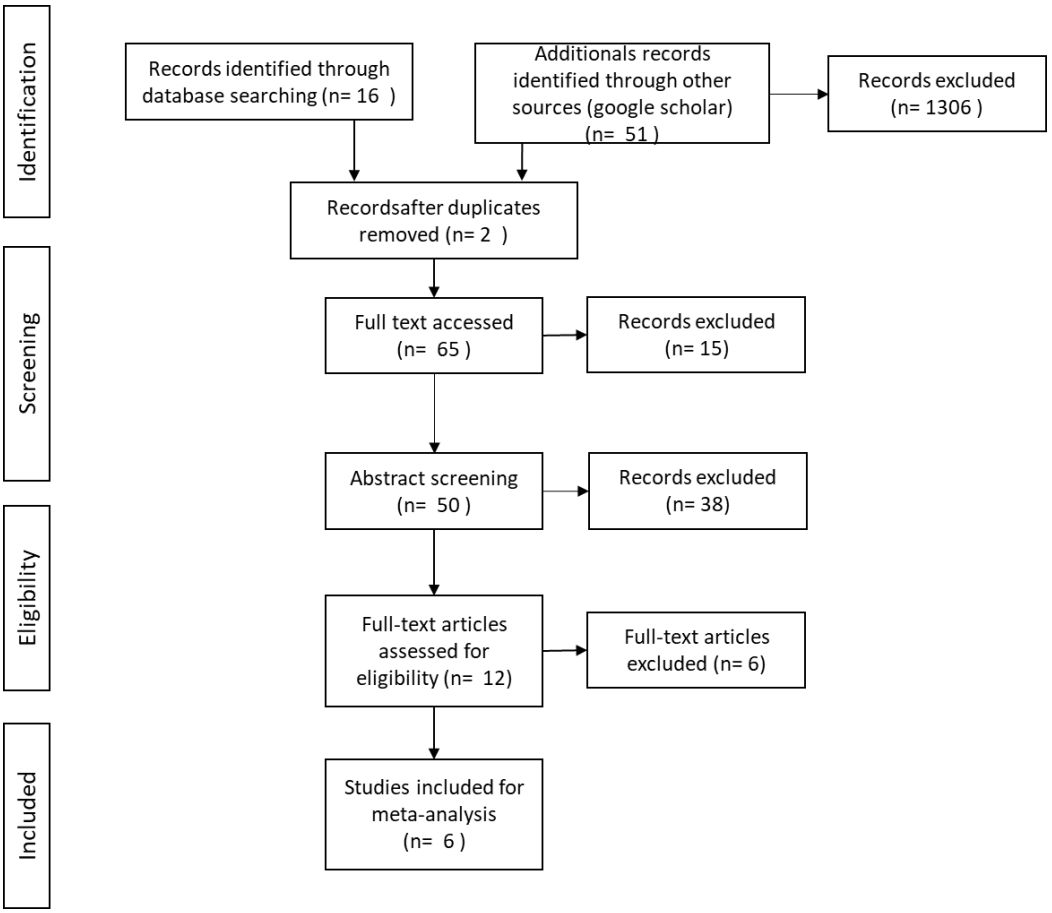

Figure 1. Flow diagram

4 Findings

After reading the Full Paper, six papers have been excluded. On the one hand, three literature reviews examine the topics of the treatment in von obesity and the virtual world (Ferrer-Garcia et al., 2013; Riva, 2011; Riva et al., 2019). These have been counter-read, and the used papers have been viewed again via a reverse-value search. Since they have no outcome themselves, they are excluded. Also, a complete book describing a general overview on the topic of nutrition in VR has been omitted. Individual results cannot be presented (Serino et al., 2016). Looking at Broderick's paper, it turns out that smoking was the issue. The smoking topic is still interesting to mention because the chosen scenario for smoking can also be found on eating behavior, according to Broderick. Here, the measurement of the biofeedback signal via SCR was successful. Since the study had already taken place in 2005, the technology was not yet fully developed, and there were interference frequency limits and movement peaks in the signal.

Nevertheless, he says that the ability to collect valid and reliable physiological data in VRstudies is warranted (Bordnick et al., 2005). The following table shows the included papers. These are further explained in the discussion if relevant

Author, year	**Title**	**Design included (n)**	**Biofeed-back-system**	**outcome-oriented**	**construct**	**effectiveness**
Pennanen et al. (2020)	Effect of virtual eating environment on consumers' evaluations of healthy and unhealthy snacks	Subject-intern experiment n=67	EEG and HVR	Healthy/unhealthy snacks in three conditions, Emotional reaction	/	VR increases eating experience and healthy food choices
Bordnick et al. (2011)	What virtual reality research in addictions can tell us about the future of obesity assessment and treatment	Case study, Future research	HVR, SCR	Abuse, drug, and alcohol	behavior	scientific gains and knowledge using VR approaches in eating addictions, to help explore new dimensions
Ledoux et al. (2013)	Using virtual reality to study food cravings	experimental study n=60	Salivation	Food craving (FC); helthy woman	/	increase FCs making diet compliance more difficult.
Lee and Shin (2013)	Effectiveness of virtual reality using video gaming technology in elderly adults with diabetes mellitus	RCT n=55	Balance, muscle strength, gait, and falls efficacy	Diabetes Mellitus and the risk of falling	/	Useful in the risk of fall for diabetes mellitus
McBride et al. (2013)	Effects of providing personalized feedback of child's obesity risk on mothers' food choices using a	RCT n=221,	Genetic-risk feedback, BMI, Family health history (FHH),	genetic and environmental risk of becoming obese. ordering in at a Virtual restaurant buffet	behavior	The risk of childhood obesity decreases when the inherited risk is communicated to mothers

	virtual reality buffet					
Sgobbi et al. (2017)	The use of sensors in virtual worlds for obesity control	Case study n=4	Motion sensor (movement)	Obesity Virtual gym and additional information	Self-determination, Present, Internet of things	Potential of increase motivation, increase the number of steps

Table 1. Combined studies with VR and Biofeedback in the field of nutrition

5 Discussion

If you take a closer look at the articles found, only very few researchers are working in this field. e.g., Riva looks at nutrition from different positions in connection with food, but not with biofeedback systems. In one of his Reviews, Riva describes how to touse the Allocentric lock theory and negative body image and that it could reduce the rate of unhealthy weight-control behavior (Riva, 2011).

Chiefly the study conducted by Pennanen shows the enormous potential of a combination of the virtual world and biofeedback and nutrition. In an experiment within the subject, virtual reality technology was used under three conditions. The emotional response to the virtual eating environment was tested and correlated with consumer desires, preferences, and hedonic ratings of healthy and unhealthy snacks. In summary, virtual reality technologies could have the potential to support the eating experience and healthy food choices by improving product evaluation. In this context, the results of EEG and heart rate measurements suggest that the consumption of a healthy snack generates more cognitive processing than an unhealthy snack. It could reduce the impact of the virtual eating environment on consumer ratings.

Strictly speaking, the study of McBride et al. (2013) does not have biofeedback in the classical sense. Still, I decided to include this study because it is an excellent example of how the virtual world with biological (here genetic) factors has a positive influence on behavior. They show that when overweight mothers order in a virtual restaurant less if they are aware of the risk of genetic inheritance. (behavioral-risk information plus personal FHH-based risk assessment)

Several included studies have little or no objective, namely the analysis of physical, nutritional behavior in the VR environment. One example is the study of Lee, who is taking care of diabetic Mellitus, which is a nutritional disease, but leaves it out and takes care of balance and gait. She also misses a deposited construct.

In general, I have expected that several studies have already dealt with nutritional behavior to strengthen the investigations. For example, by recording stress levels or heart rates. There is a huge opportunity to develop the work of researchers further and to enhance the evidence with validatable parameters that can be used in clinical practice.

6 Conclusion and Outlook

The results primarily provide an overview of existing research in the field of VR-related technology in nutrition research with validation by biofeedback systems. It shows that there is research in the field of virtual technology in combination with either nutrition or biofeedback systems but rarely a combination. Theoretical constructs from a technology point of view are not found in any of the included papers; however, if psychological theories are used to put them into a broader framework, further research is needed. Thus, a lack of theoretical foundations for a synergetic approach of medically practical technical support is noted but found separate theoretical foundations in research to build on future work.

Overall, VR-related technologies appear to be a promising and dynamic approach to improve the possibilities and effectiveness of nutrition therapy. The review shows a gap for further research. Research gap of combined VR with biofeedback, especially in the area of nutrition.

The limitations of the paper are that a single author wrote this article and that the literature search was conducted from only one perspective.

For my future work, relevant motivational approaches from the health psychological HAPA approach will be integrated for the first time in such a VR and AR environment by training implementation and coping intentions as well as motivational self-regulation strategies to ensure greater success in changing behavior and maintaining success in the long term (e.g., (Ressing et al., 2020)

The recording of physiological values should be standardization in VR research in the health sector so that VR can be recognized in clinical practices and thus, prevention and therapy. Coming back to the research question, it is not yet possible to establish a link between nutritional (motivational) factors, VR, and biofeedback systems.

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What Are You Looking At? Using Eye Tracking to improve Learning in Virtual Environments

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Abstract. Learning in Virtual Reality (VR) is an emerging topic characterized by opposing theories. The interest theory hypothesizes that students who learned in immersive VR would report more positive ratings of interest and motivation and would thus score higher on a test covering the lesson learned. On the other hand, the cognitive theory of multimedia learning assumes that students who learned with a classic medium would score higher on a test covering the lesson learned, while reporting lower in terms of interest and motivation. In this proposal, I focus on the concept of learning in VR, which is an emerging concept in information science (IS) research that can be studied using neurological measures such as eye tracking. While previous literature has provided initial evidence of the feasibility of eye tracking in a learning context, this study seeks to investigate how well eye tracking performs when it comes to detecting items inducing superfluous cognitive load in a VR setting.

Keywords: Virtual Reality, Eye Tracking, Learning, Cognitive Load, Knowledge Transfer

1 Introduction

Philosophy, psychology or, neuroscience; the main body of studies within the cognitive science research draws from education and learning research in order to explain how the human mind works (Schunk, 2009). A major goal is to bridge the gap between the fields through a direct dialogue between researchers and educators, thus enabling a better instructional design of the factors that stimulate knowledge acquisition.

IS-Research on the other hand tries to use the knowledge gained from education and learning research to apply it to new forms of media. VR offers the benefit of unique experiences that enable active learning without distraction (Martín-Gutiérrez et al., 2017). Some researchers describe immersive VR as a more motivating and engaging learning medium compared to non-immersive media (e.g., Makransky, Terkildsen, & Mayer, 2019; Parong & Mayer, 2018). Other researchers claim that VR creates additional cognitive load induced by superfluous visual effects, hence reducing the learner's performance (Makransky, Terkildsen, & Mayer, 2019; Mayer, 2014; Parong & Mayer, 2018).

Many head-mounted displays (HMDs) have integrated sensors to track the position and orientation of the user as well as their hand positions measured by the controller in the virtual space (Siegrist et al., 2019). However, only few research has taken advantage of eye tracking in combination with consumer-HMDs

to expand its use beyond desktop computers (Vasseur et al., 2019).

The quantifiable data gathered from gaze detection can help us to improve virtual learning scenarios by promoting visual expertise with the generation of eye movement modeling examples (Holmqvist et al., 2017; Zhao et al., 2017). To better understand the concept of learning in VR, this study proposes an experiment to use eye tracking in order to improve learning material by detecting cognitive load inducing factors. The remainder is structured as follows: First, I briefly review the concept of learning in the context of VR and how it is measured (section 2). In section 3, I propose an experimental setting that allows me to investigate VR-learning scenarios with the help of eye tracking. I conclude by reflecting on potential insights and future directions of this research.

2 Related Work

Few studies propose that immersive VR and the feeling of presence yield worse learning outcomes than non-immersive media (such as Microsoft PowerPoint slides) (Makransky, Terkildsen, & Mayer, 2019). The cognitive theory of multimedia learning (Mayer, 2009, 2014) as well as the cognitive load theory (Sweller et al., 2011) attribute extraneous processing to VR-usage. Features, such as additionally induced visual effects evoke cognitive processing that is not relevant to the instructional goal.

However, competing theories exist. For instance interest theory suggest that students learn more intensively when they value the content or are elicited by the situation (Dewey, 1913). Researchers that probed for learning interest and motivation in line with these theories and restructured their experiments accordingly, were able to achieve learning success in an immersive VR-environment (e.g., Kampling, 2018; Markowitz et al., 2018; Parong & Mayer, 2018). As such, Parong and Mayer (2018) performed experiments while adjusting specific factors to apply the cognitive theory of multimedia learning as well as the interest theory to result in a successful, highly motivational learning experience. In order to acquire data of excessive cognitive processing, while still providing the motivational aspect of VR, the user's attention within the software has to be measured.

Literature uses eye tracking to analyze attention in a learning context. I summarized the results of my literature analysis in Table 1, confirming that eye tracking performed on a desktop computer is rather common in IS literature, yet only little research has been done to analyze mobile eye tracking in a similar context (Vasseur et al., 2019). Since VR-eye tracking provides the respondent with full flexibility regarding natural movements in a fully immersive 3D environment, a combination of the strengths of mobile and desktop-based eye tracking can be achieved (Meißner et al., 2019). In order to fully benefit from mobile eye tracking, I excluded literature that used Cave Automatic Virtual Environment (CAVE) devices as they restrict the space of movement, are unaffordable for most consumers compared to HMD devices, yet do not provide significant advantages in terms of immersion (Mallaro et al., 2017). VR eye tracking literature that uses HMDs is scarce. My findings mostly confine to examinations of VR eye tracking fundamentals, including challenges, alleviation of usability issues as well as setup, optimizations (Clay et al., 2019; McNamara & Jain, 2019). As such, Clay et al., (2019) describe the process of bringing VR in combination with eye tracking into the lab in order to inspire ideas for new experiments. Few studies performed experiments to acquire quantitative data from VR-eye tracking (Clay et al., 2019; Duchowski et al., 2000; Khamis et al., 2018). Nevertheless, none of the presented research analyzed virtual environments using eye tracking with the goal of learning performance maximization.

A large set of research focussed on learning or attention detection using eye tracking (see Table 1). Large proportions dealt with the risks

of automobile crashes due to unmindfulness especially in context of autonomous driving (Hatfield et al., 2019; He et al., 2011; Huang et al., 2019). Other researchers also probing for attention tasks, familiarized test subjects with massive open online courses. Arguing from a perspective of the working memory, Zhao et al. (2017), successfully used eye tracking to improve the instructional design of computer-based learning and testing environments. Additionally, research within the Educational Science domain more and more uses eye tracking to shed light on expertise and its development in visual domains as well as promote visual expertise by means of eye movement modeling examples (Holmqvist et al., 2017).

The opposing ideologies 'interest theory' and 'cognitive theory of multimedia learning' suggest that learning in VR will motivate students to work harder while cognitive overload will hinder their learning success. As Educational Science research suggests, eye tracking can be used to create better learning material by detecting items that create superfluous cognitive load (Holmqvist et al., 2017; Zhao et al., 2017). With the following experimental setting I seek to research virtual environment fidelity settings that allow for an improvement of learning performance detected by using eye tracking data.

VR	Learning	Eye Tracking	Example references
✓	✓		(Butavicius et al., 2012; Gordon et al., 2019; Kampling, 2018; Kampling et al., 2019; Makransky, Terkildsen, & Mayer, 2019; Makransky, Wismer, & Mayer, 2019; Markowitz et al., 2018; Parong & Mayer, 2018; Sense & van Rijn, 2018)
✓		✓	(Clay et al., 2019; Duchowski et al., 2000; Khamis et al., 2018; McNamara & Jain, 2019; Siegrist et al., 2019)
	✓	✓	(Gwizdka, 2019; Hatfield et al., 2019; He et al., 2011; Holmqvist et al., 2017; Huang et al., 2019; Hutt et al., 2016; Hutt et al., 2019; Reichle et al., 2010; Robison et al., 2017; Steindorf & Rummel, 2020)
✓	✓	✓	**(this study)**

Table 2 Literature analysis

3 Methods

60 experimentees will be assigned to one of two groups. Both groups will be assigned to participate in a guided crane maintenance task. One group will benefit from the detailed environments with high quality textures, while the other group will experience an environment that has been reduced to only the crane as well as the necessary tools. Stimuli delivery and eye tracking will be conducted using HTC Vive PRO Eye SRanipal SDK, will be developed using the Unity engine and delivered using SteamVR. Participants will be screened for normal or corrected-to-normal eyesight, use of upper limbs and proficiency in English or German. Subjects will be informed that we are investigating their gaze in a simulated work environment. I will seek approval from our university's research ethics board and each session will last for 30 minutes in a controlled setting. At the completion of each session, participants will receive 15€.

3.1 Procedure and Materials

Experimentees will undergo a consent protocol, complete an initial demographic questionnaire, will then be fitted with the HTC Vive PRO Eye VR-system and undergo a calibration routine. Participants will then take part in a virtual crane maintenance task. The subjects will find

themselves in a harbor setting with a crane that is only accessible from the side of the brink, otherwise surrounded by cargo. The high fidelity group, however will additionally see some boats, ships and yachts in the background moving across the harbor. Both groups are given a series of gradual, textual instructions which will guide the subjects through the different maintenance steps (e.g., visual examination or applying grease to the chain), each comprised of several substeps. Following the VR session, participants will undergo a debriefing.

3.2 Questionnaires and Physiological Measures

As suggested by Peper & Mayer (1986) or Coleman et al., (1997), the subjects will be interrupted after every step in order to summarize the procedure. This shall increase the learning outcome. Following the experiment, participants will complete a postquestionnaire to make self-ratings about their effort and understanding, their motivation, their interest for the subject, their engagement with the lesson, and their mood (Parong & Mayer, 2018). Followed by the questionnaire, subjects will complete a posttest with 20 questions based on the lesson.

Additionally, performance related indicators such as maintenance time, execution precision, tool waste, as well as task success will be recorded by the software. Eye tracking behavior will be analyzed in 2 second epochs preceding each event. Epochs will be investigated for pupil diameter, gaze fixation, search behavior and task completion time.

3.3 Data Analysis

Each participant is expected to yield between 5000 and 7000 epochs. Multivariate linear regression will be used to assess the effects of the measures reported. The acquired gaze data will be mapped to the posttest results as well as the information gathered by the software itself.

4 Outlook

Although the field of VR learning is growing, research is short of "experimental quantitative approach[es]" (Kampling et al., 2019). Consequently, this study seeks to extend current insights in terms of how to improve VR learning scenarios to be on par or better than classic learning scenarios. With better knowledge of factors that have a direct impact cognitive processing induction within VR, we can uncover new insights into how to design our virtual environments. VR promises to help create realistic, yet controlled environments which make new research directions possible.

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Exploring the Potential of Virtual Reality for Learning –A Systematic Literature Review

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Abstract. With the recent advent of affordable consumer technologies like Oculus Rift and gadgets from other technology companies as HTC, Google, or Samsung, virtual reality has gained enormous popularity. Offering unique characteristics like the feeling of being in a virtual space and a natural interaction with objects in this space, virtual reality has also been part of research as a promising learning tool. However, results in this context are mixed. Using the approach of a systematic literature review, this research scrutinizes these different results and contradictory theories. The outcomes present which theoretical approaches have been taken to explain learning and which factors are essential regarding the design of a virtual space. Furthermore, this research identifies future research opportunities to better understand and unfold the potential of virtual reality for learning.

Keywords: Virtual Reality, Individual Learning, Learning Theories, Systematic Review, Literature Review

1 Introduction

Trying to understand the process of learning has a long tradition (Illeris, 2018; Schunk, 2012). This is also reflected in the different streams and paradigms of philosophy, psychology, or neuroscience, which try to understand learning and to explain how the human mind works (Schunk, 2012). The rationale behind this endeavor is to gather a more profound understanding and enable a better instructional design that fosters knowledge acquisition. The idea of using Information Technology (IT) in this frame of reference is not new. It was conceived in the 1940s when Bush introduced the concept of his well-known 'Memex' (Bush, 1945). With further expansion and development (Baskerville, 2011), IT also played an increasingly important role in the context of learning. In particular Virtual Reality (VR), with its unique features and accessibility today offers the possibility to create new opportunities that support learning. One of the most powerful features in favor of VR is its ability to create a perceptual illusion (i.e., a feeling of being in a virtual space; Slater, 2018). Furthermore, the VR devices provide controllers to interact within VR (Anthes et al., 2016). These allow tracking and natural interaction with objects like in the real world (Nanjappan et al., 2018). Thus, VR offers the benefit of interactive experiences that enable active learning without distraction (Martín-Gutiérrez et al., 2017). For example, it is possible to immerse in VR and train in dangerous environments (Lathan et al.,

2002), visualize scenarios that are not visible in the real world (Kampling, 2018b), or train and test psychomotor skills before they can be used in the real world (Aggarwal et al., 2006). However, results on learning in VR are mixed. As such, my research objective is to provide a systematic synthesis of which theoretical approaches have been taken that explain learning in VR and what are distinct factors that influence the learning success. In this way, I would like to provide an essential foundation on which researchers and practitioners can draw from. Practitioners can use the insights to design VR scenarios in such a way that the technology can unleash its full potential as a learning tool, and researchers can use it to gain an overview to facilitate future theory development.

In order to address the objectives, the remainder of this paper is structured as follows: In section two, I briefly review the technology and concept of VR as well as an overview of learning in VR. Then, I explain the methodological approach in detail. Section four presents the results. I conclude by discussing the findings in section five.

2 Related Work

Since the advent of Oculus Rift and gadgets from other technology companies as HTC, Google, or Samsung, affordable and immersive consumer technologies became omnipresent (Castelvecchi, 2016). These VR devices are often multi-sensory, head-mounted displays (HMDs) (Anthes et al., 2016). The HMDs have a head tracking system that updates the left and right vision (i.e., the stereo vision) to match the user's head movements within VR (Slater, 2009). Integrated headphones deliver audio (Slater, 2009)[2]. The concept of VR is besides its technological components (i.e., software and hardware to create a 3D environment) mainly characterized by three features, namely immersion, the feeling of being present in VR, and interaction with the VR environment. This is also reflected in the definitions. Wexelblat (1993), for example, described VR as a computer-generated, interactive, 3D environment in which people become immersed. Gigante (1993) characterized VR as: "*The illusion of participation in a synthetic environment rather than external observation of such an environment. VR relies on a 3D, stereoscopic head-tracker displays, hand/body tracking, and binaural sound. VR is an immersive, multi-sensory experience*" (p. 3). Burdea and Coiffet (2003) defined VR as "*a high-end user-computer interface that involves realtime simulation and interactions through multiple sensorial channels. These sensorial modalities are visual, auditory, tactile, smell, and taste*" (p. 3). Moreover, Riva (2007) defines VR, as "*a simulated environment in which a perceiver experiences the feeling of presence by means of a communication medium, a phenomenon referred to as telepresence*" (p. 1240). These features are also the reason why VR is unique and seen as promising in the context of learning [3].

In this respect, it is not surprising that a multitude of theoretical approaches was used to compare VR with other media and to examine specific design aspects. However, the results of learning in VR are mixed. While one stream presents VR as a superior media format for learning (e.g., Butavicius et al., 2012; Dubovi et al., 2017; Lee & Wong, 2014), another stream does not confirm these results (e.g., Leder et al., 2019; Makransky, Terkildsen, & Mayer, 2019; Parong & Mayer, 2018). The present study, therefore, attempts to shed some light on the issue by providing and reviewing the status quo.

3 Methodology

To achieve the objectives, I conducted a systematic literature review (Boell & Cecez-Kecmanovic, 2015; vom Brocke et al., 2009;

[2] For a for a state-of-the-art review of the technology see Anthes et al. (2016).

[3] See Slater (2009) and Schultze (2010) for a comprehensive description of the conceptual properties of VR.

Webster & Watson, 2002) and followed a proposed five-step procedure as suggested by vom Brocke et al. (2009).

(1) In the first step, I used the taxonomy of Cooper (1988) to define the review scope. According to this taxonomy, I mainly focus on the research outcomes but also on the other areas. The goal of the review is to synthesize and to integrate findings of prior work on learning in VR to purvey a status quo and to give advice on how scholars can further extend the current body of knowledge. Since I am interested in learning in VR, I organize the results conceptually (i.e., used theories and concepts). To achieve this goal, I espouse a neutral perspective to inform general and specialized scholars as well as practitioners on learning in VR. Furthermore, the review aims to representatively cover pivotal learning research on VR by including the databases Business Source Complete, PsycInfo, PsycArticles, and AISeL. I focused on these databases because they cover a substantial body of knowledge within the IS field and also educational psychology.

(2) In the second step, it is suggested to give a broad conception of the topic. Therefore, I provided a brief overview in the previous chapter.

(3) Step three involves the literature search. The search included the databases Business Source Complete, PsycInfo, and PsycArticles, which were accessed via EBSCOHost. I furthermore included the database AISeL (accessed via the website: https://aisel.aisnet.org/) to cover further related IS (Information Systems) work on learning in VR. To find relevant papers, I chose the search term 'learning' and 'virtual reality' (search string: TI "learning" AND TI "virtual reality"). I used the keyword 'learning' because there is no uniform term for the measurement of learning outcomes. Thus, 'learning' ensures that several variations (e.g., learning effectiveness or learning performance) are included. The search was focused on searching the keywords within the title and was limited to publications within the last ten years to retrieve only related and current research. I am aware that this strategy may exclude some relevant results, but as I am mainly focused on the current results of learning in VR, these keywords should be mostly contained within the title of relevant work. The literature search was conducted between July 2019 and December 2019 and yielded initially 95 hits (EBSCOHost: 88 hits; AISeL: 7 hits). Then, I filtered the search results to peer-reviewed scientific articles (72 hits left – exclusion of 22 hits in EBSCOHost) and excluded research that was not published in English (71 hits left – exclusion of 1 hit in EBSCOHost) via the EBSCOHost filters and in AISeL manually. After skipping duplicates (2 duplicates in EBSCOHost), 69 articles remained. Then, each article was scrutinized with a focus on the abstract, participants, procedure, and learning measurement. Based on this reading, further 42 articles that did not meet the inclusion criteria were excluded (see **Fehler! Verweisquelle konnte nicht gefunden werden.** for all inclusion-/exclusion criteria). In total, 27 articles were left after this scanning procedure. These 27 articles were then selected for cataloging and thorough reading. Each article was presented by its journal, author(s), theoretical approach(es), research objective(s), the domain of learning, measurement approach of learning, factors influencing learning, and the used VR technology.

Inclusion criteria	**Exclusion criteria**
Peer-reviewed research	Nonscientific source
The article is written in English	The article is not written in English
The article examines learning in 3D-VR	The article does not examine learning in 3D-VR

The article provides empirical results on learning	The article does not provide empirical results on learning
Sample without special needs	Sample with special needs

Table 3. Inclusion and exclusion criteria

(4) Step four deals with the analysis and synthesis of the relevant literature. To analyze literature on learning in VR, I scrutinized factors making learning in VR different from learning in other environments. Particularly, I analyzed the theoretical approaches as well as the results to inform about factors influencing learning in VR. To do so, I only considered theories that were a) undermined with an explanation of how they may affect learning and b) included measurement of the underlying constructs. The results are presented in the following chapter 4.

(5) The last step of a review is the formulation of a research agenda. The agenda is provided in the discussion in chapter 5.

4 Results

The examined research used several approaches to explain learning in VR. On the one hand, medium-independent learning theories have been investigated to compare different media. On the other hand, theories and concepts have investigated specific forms of learning or design aspects in VR. In the following, I briefly introduce all the theories and concepts used and show related results:

Cognitive Load Theory (CLT) & Cognitive Theory of Multimedia Learning (CTML). The CLT proposes that capacity in the working memory is limited (Sweller et al., 2011). The cognitive load refers to the total amount of resources needed to process information (Sweller et al., 2011). The theory distinguishes three types of cognitive load: intrinsic cognitive load, germane cognitive load, and extraneous cognitive load (Sweller et al., 2011). The intrinsic cognitive load refers to the loads created by the difficulty levels of teaching materials for learners and is difficult to manipulate by the instructional design (Sweller et al., 1998). The extraneous cognitive load is induced by the learning material or the type of media presentation, which can be changed by instructional designs (Sweller et al., 1998). The germane cognitive load is linked to learners' degree of concentration and ability of schema acquisition that are affected by the organization of teaching material and type of media presentation (Paas et al., 2003). Hence, it can also be altered by instructional design (Paas et al., 2003). In order to process information properly, memory resources should not be exceeded (Sweller et al., 2011). CTML builds upon the CLT and assumes that humans process information in separate channels (i.e., an auditorial/verbal channel for narration, sounds, etc. and a visual/pictorial channel for animations, videos, etc.), have a limited capacity in working memory (i.e., they can only process a limited amount of information per channel at one time) and that meaningful learning requires active cognitive processing (Mayer, 2009). Based on this, the theory derived several principles (12 principles in total) to optimize instruction according to the mentioned assumptions (cf. Mayer, 2009). Makransky, Terkildsen, and Mayer (2019) and Parong and Mayer (2018) argue based on the CTML that high immersive VR requires higher cognitive load (because of more extraneous details) and thus focus on important facts is decreased. These studies showed indeed that high immersive VR yields higher cognitive load and is less effective in learning than with presentation slides (Parong & Mayer, 2018) or in a PC Lab (desktop VR) (Makransky, Terkildsen, & Mayer, 2019). This is in line with

the coherence principle (i.e., people learn better when extraneous material is excluded) of the CTML. However, it has been shown that this effect can be repealed by applying the segmenting principle (i.e., learning material should be presented in user-paced segments rather than a continuous unit), which enables better processing of information (Parong & Mayer, 2018). Research has also shown that VR does not always lead to a higher cognitive load. Lee and Wong (2014) showed the opposite for low-spatial ability learners. In this case, learning with desktop VR is better than with presentation slides. They explain this issue with a higher extraneous cognitive load resulting from the transformation of 2D objects into 3D in the slideshow, suggesting an aptitude-treatment-interaction. Furthermore, Kartiko et al. (2010) found that the visual complexity of animated virtual characters is not a crucial facet that influences cognitive load and learning. Other results of the CTML highlight that the redundancy principle (i.e., animation and narration yields better learning than learning with additional visual text information) was not supported in VR (Makransky, Terkildsen, & Mayer, 2019). Makransky, Terkildsen, and Mayer (2019) argue that the design could have been responsible for the results (i.e., students just listened instead of reading, which is also supported by results of the cognitive load).

Interest Theory (INT). Parong and Mayer (2018) further investigated INT as an opposing approach, which proposes that learners learn more intensively when they value the content or are elicited by the situation (Dewey, 1913). The rationale behind this idea is that VR could be able to foster situational interest, which would yield deeper processing of the learning material. However, while immersive VR can enhance motivation, engagement, and enjoyment, it was not superior in terms of learning (Parong & Mayer, 2018).

Embodied Cognition (EC). An additional cognitive approach to explain learning is EC. Often it refers to the role of the body as 'conditio sine qua non', meaning that "*aspects of the agent's body beyond the brain play a significant causal or physically constitutive role in cognitive processing*" (R. A. Wilson & Foglia, 2019). However, there are several views on EC (M. Wilson, 2002) . Yuviler-Gavish et al. (2014) examined embodied cognition in terms of observational learning. Based on the hypothesis 'cognition is for action', they argue that the visual system can prime motor functions. Results show that in comparison to an enactive approach (i.e., performing physical action), partly observational learning (i.e., performing only a specific task of the whole procedure) is equal in learning performance (i.e., errors at a real-world task) but more efficient (i.e., less time consuming). However, Jang et al. (2017) found in a yoked-pair design that direct manipulation of an anatomic structure promotes better learning (i.e., participants were able to reconstruct/draw better the structure) than merely observing. They assume that direct manipulation yielded alignment between the perceived structure and one's own body, which in turn facilitates learning. Gordon et al. (2019) also observed that both forms, learning through sensorimotor experience as well as observation (albeit less), promote language learning. Besides, with a different focus, Markowitz et al. (2018) argue that 'cognition is situated' and immersive VR supports situated action. Therefore, they exploratively investigated different forms of self-avatars to see if a particular avatar embodiment engages the user to create stronger social and psychological attachments to an environment and thus increases learning. However, results did not yield any differences in learning outcomes.

Interactive Information Processing Model (IIPM). In contrast, the idea of Markowitz et al. (2018) bases on an interactive information process, assuming that interactivity with media, elaborative cognitive processing, and information recall are positively associated (Tremayne & Dunwoody, 2001). Their results support this assumption. They show that more

interactive participants (more exploration of VR environment) achieve better learning success.

Reward-Based Learning (RBL). RBL can be described as a reinforced positive feedback loop (i.e., the desired action is associated with a reward which forms a positive loop; Bourgeois et al., 2018). Two studies that used this approach showed that rewards could be an element to foster learning in VR (Bourgeois et al., 2018; Marsh et al., 2010). Interestingly, however, the spatial placement of the rewards seems to play a crucial role, as there are biases (rewards on the left side are better recognized; Bourgeois et al., 2018).

Matching Hypothesis (MH). The MH of Makransky, Wismer, and Mayer (2019) states that a pedagogical agent in VR can enhance learning if the learner can identify with her/him. Results indicate that if the pedagogical agent matches the learner characteristics (e.g., by gender), then the learning outcomes are better.

Presence. The characteristic of presence is generally the rationale for using immersive VR for learning. Accordingly, research frequently included this concept. Presence is often described as the illusion or the feeling of being there (Schultze, 2010). The results in terms of learning are mixed. While some studies report a positive influence on learning (Dubovi et al., 2017; Kampling, 2018a, 2018b; Lee et al., 2010; Markowitz et al., 2018) other do not report an effect (Kartiko et al., 2010; Leder et al., 2019; Makransky, Terkildsen, & Mayer, 2019).

Immersion. A further approach used was cognitive absorption or, more precisely, the sub-dimension immersion. It is described as an experience of total engagement (Agarwal & Karahanna, 2000). The results show mixed results (Kampling, 2018a, 2018b; Kampling et al., 2019). On the one hand, quantitative results show that this concept does negatively affect learning (Kampling, 2018a). In detail, it was shown that immersion does not have an influence on learning performance but a negative effect on perceived learning effectiveness. On the other hand, qualitative insights suggest a positive impact on learning (Kampling, 2018b; Kampling et al., 2019).

5 Discussion

First of all, literature shows that there is still a lack of research on learning in immersive VR. Regarding the technology, it is surprising that only 13 of the examined 27 papers used immersion supporting technologies like a HMD (e.g., HTC Vive, Oculus Rift, Samsung Gear VR) or CAVE in the last ten years.

Second, the results on learning in VR are mixed, and research used a plethora of theoretical approaches to explain different aspects of learning in VR. On the one hand, immersive VR shapes a feeling of presence (e.g., Kampling, 2018a; Makransky, Wismer, & Mayer, 2019; Markowitz et al., 2018), yielding total engagement with VR (e.g., Kampling, 2018a). Therefore, attention is entirely focused on VR, and distractors are suppressed (Kampling, 2018a; Martín-Gutiérrez et al., 2017), which improves learning (e.g., Kampling, 2018b; Markowitz et al., 2018). On the other hand, theories like the CLT and CTML propose that immersive VR induces higher extraneous cognitive load, which in turn decreases learning (Makransky, Terkildsen, & Mayer, 2019; Mayer, 2009). Makransky, Terkildsen, and Mayer assume that "*added immersion can interfere with reflection as the entertainment value of the environment does not give the learner ample time to cognitively assimilate new information to existing schemas*" (Makransky, Terkildsen, & Mayer, 2019, pp. 233–234). However, both explanations show mixed results as highlighted in chapter 4. As such, VR can be considered as a promising tool for learning if specific factors are taken into account. In particular, against the backdrop that immersive VR is more motivating and engaging than non-immersive media (e.g., Makransky, Terkildsen, & Mayer, 2019; Parong & Mayer, 2018). This should not be neglected as there is evidence that situational interest can be a first

step in promoting learning (Renninger & Hidi, 2016).

Overall, these results suggest that further research needed to use the power of immersive VR without inducing too much extraneous cognitive load. In this line, for example, I would suggest combining VR and eye-tracking to objectively identify cognitively distracting and overstraining factors within VR. Also, in the light of the concept of social presence (Schultze & Brooks, 2019) and the findings of the MH (Makransky, Wismer, & Mayer, 2019), it should be further investigated which other characteristics of an avatar, taking into account demographic variables, positively influence learning outcomes. In addition, future research should include longitudinal studies to evaluate motivation and learning outcomes over time. Finally, the context in which learning took place was mostly scientific learning. As Parong and Mayer (2018) also suggest, research should include other teaching materials and further authentic learning settings.

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A Design Journey: Towards a Virtual Reality Simulation and Training Application

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Abstract. Through digital transformation and new technologies such as virtual reality (VR), employees can benefit from enormous advantages within the corporate context. In industrial computer-aided design (CAD), there are complex workflows that have a great influence on the maintenance processes. However, designers may not be fully aware of potential benefits of these influences. To sharpen this awareness, for such scenarios the demonstration of CAD objects in VR can be a solution. Virtual testing of a design is inexpensive and can be realized quickly. In addition, maintenance can already be trained virtual in detail on the VR image of the machines. This topic is taken up representatively and implemented in an information system (IS) based on VR and a design science research approach. The needs of the employees are strongly considered in this study and the developed software can be applied to a broad class of related problems. Finally, the demonstrator and the underlying processes will be evaluated to gain insights and knowledge about the design of a VR system.

Keywords: Digital Transformation, Virtual Reality, Design Science Research Methodology, Knowledge Transfer, Hybrid Value Chains

1 Introduction

In the course of digital transformation, the virtual and real worlds of work are increasingly merging (Friess, 2016). Products and services are equally subject to this process. The contribution, especially of highly specialized technical products, can be significantly increased by combining them with accompanying services (Vendrell-Herrero et al., 2017). Accordingly, it is necessary for products and services (such as construction and maintenance processes) to merge. To this end, the necessary competencies on the part of both producers and service providers must be identified and jointly expanded.

The value chain is the term used to describe various stages of production that can be described as an ordered sequence of activities. These activities create value, consume resources and are linked together in processes (Porter & Advantage, 1985). However, nowadays value chains are usually modified to hybrid value chains. This means that not only the product but also the services associated with the product are defined as hybrid value chains (Leimeister & Glauner, 2008).

This research aims to address the development process for an interactive VR demonstrator for the mediation of competencies over hybrid value chains (construction processes and workflows around maintenance) (Weigel, Hoffmann, et al., 2020). In addition to the conception of a digital environment for experience-based and subject-related competence development, the exchange of knowledge between maintenance personnel and other relevant employees (constructors, management, sales, information technology (IT), etc.) across departments and companies should be supported.

In the research process, both theoretical and practical elements in the VR demonstrator are illustrated in order to promote the transfer of knowledge along hybrid value chains. To better define this VR demonstrator, the relevant requirements and practices of the employees should first be determined empirically. Subsequently, the competence development is conceptualized in organizational terms (Weigel, Heger, et al., 2020). The aim is to provide employees with the best possible support in their competence development through the use of VR and to transfer this support into operational practice on a pilot basis.

This research is structured as follows: First, an overview of the related work on hybrid value chains, technology-supported perspective taking and VR will be given. Next, the research methodology based on the research framework of design science will be described (Peffers et al., 2007). Third, the results will be discussed and the limits of the research to date will be pointed out. Finally, a recommendation for future research will follow.

2 Related Work

In hybrid value chains, the alignment of corporate strategies is particularly important. Often, several organizations are represented in these hybrid value chains (Santos et al., 2015). They pursue different goals and strategies. However, good cooperation is characterized by the fact that these different organizations pursue similar goals. IT-Business Alignment considers the alignment of IT and business, (Reich & Benbasat, 1996). IT-Business Alignment will become increasingly important considering hybrid value chains between organizations (Ryan et al., 2013; Weigel, Hoffmann, et al., 2020).

One way to strengthen this IT-Business Alignment can be the technology-supported perspective taking (Weigel, Hoffmann, et al., 2020). The perspective taking originally comes from psychological research. It is an attempt to enable one person to take the perspective of another person (Boland Jr & Tenkasi, 1995). The literature often describe this empathy as a reflection of our own point of view. Customer and user orientation can be understood as a form of adopting a perspective that has a positive effect on the development of new products (Salomo et al., 2003). But also in the context of services, the ability to adopt the perspective of another client, has a positive effect on the ability to help (Axtell et al., 2007). Classically, perspective taking can be triggered by the explicit request to put oneself in the perspective of another person (Boland Jr & Tenkasi, 1995). However, digital technological developments in particular increasingly show that the adoption of the perspective can also be influenced by technical measures (Lee et al., 2018; Peng et al., 2017).

VR has enormous potential when it comes to teaching skills and processes. This has already been researched within the framework of VR research in the educational sector. (Wohlgenannt et al., 2019). Objects and even individual process steps can be displayed with a very high level of detail. In addition, a closed VR room enables a focused interactive experience (Martín-Gutiérrez et al., 2017). However, VR technologies can also be used to close a gap in the transfer of information (Jayaram et al., 1997). Nevertheless, research on the use of VR in the context of technology-supported perspective taking is limited (Weigel, Hoffmann, et al., 2020). There are only a few

articles dealing with use cases in a business context. For example, it is argued that the combination of avatar manipulation and role-playing in the virtual world can also lead to the development of empathy (Jestice, 2016). This avatar manipulation was also considered in another experiment. Here, the conventional method of taking perspectives by means of mental simulation was combined with the immersive virtual environment. Different effects were observed depending on the group. For example, the negative effect of age discrimination was less pronounced if one was placed in the role of an older person in VR (Oh et al., 2016).

In summary, hybrid value chains are a decisive factor in our today's economy. The better they function, the better the objectives of the various organizations are aligned. But not only the general objectives plays a role, but also the IT-Business Alignment. This IT-business orientation can be supported by technology-supported perspective taking, and VR can be a manifestation of this support.

3 Methodology

Design science research has become increasingly important in the research field of IS since the 1990s (March & Smith, 1995). But even today, the importance of design science research remains undiminished (Niehaves & Ortbach, 2016; Peffers et al., 2007). There are two areas of design science. One deals with the creation of a new IT artifact. The other one deals with the manipulation of an existing IT artifact. This current research shows that theoretical approaches to the influence and effects of e.g. IT artefacts only emerge after their development and use (Hevner et al., 2004).

This research follows the six phases of the design science research methodology for information systems research (Peffers et al., 2007). These are:

1. Identify problem and motivate

2. Define objectives of a solution

3. Design and development

4. Demonstration

5. Evaluation

6. Communication

First, an analysis of the existing processes was carried out to determine the exact procedures. An important part at this point was the understanding of the process knowledge. At the same time, the search for existing best practices was carried out. The technical possibilities for implementing a VR environment were explored. After an overview of the initial situation and the feasibility of the VR environment was available, the requirements for the demonstrator were determined.

Furthermore, a concept was developed how the VR environment should represent the researched approaches and the collected data. This step was followed by the actual development of the demonstrator. It was evaluated at regular intervals whether the demonstrator meets the requirements and the concept. This evaluation can be included in the further development. The steps of development and regular evaluation are currently repeated until the development goals are achieved. As a final step, the development of this prototype or a further application is discussed.

To date, phases one and two have been completed. Phases three and four are currently active, phases five and six will follow in the future.

3.1 Problem definition

In this research two organizations are considered, which are connected in a hybrid value chain. First, the producing organization and second an organization that offers accompanying services for the products. In order to define the problem situation precisely, interviews were conducted with six employees of the production organization and five employees of the service organization. The interviews provide good insights into the current situation. For example, maintenance

work on a technical machine requires a head for heights and enormous skills. However, the person who maintains a machine is usually not the person who designs the machine. This means that there are knowledge gaps in the value chain between the services of assembly, maintenance, repair and product development. Therefore, important aspects for maintenance cannot be taken into account in the design.

It is obvious that this workflow offers the potential for improvements through digital transformation, more precisely through the VR demonstrator under consideration. On the one hand, competence development along the hybrid value chain has not been consistently pursued so far. On the other hand, there is no real evaluation of the service processes in relation to the actual construction of the product. There is uncertainty for all involved employees about the possibilities of the employees of the other organization.

3.2 Objective of Solution

The interviews from phase 1 were used to develop the objective of solution. This was pursued extensively, since previous research on VR environments has only marginally addressed the industrial context. Therefore the solution is planned in a cooperative, employee-centered approach. One example is a service employee who was accompanied on two days. During these two days, maintenance work on two different machines could be observed and scientifically documented. For this purpose the individual steps were recorded photographically. Due to the industrial environment and the applicable regulations, it was not possible to record the process on video. A maintenance manual was created from the documentation and photos, which was later discussed again with the service personnel to check for possible misunderstandings. The product development process was also documented in detail. A product development process was accompanied, from the integration of the standard parts to the static calculation of the designed product the steps could be traced.

The identified requirements can be specified as follows. This specification provides the basis for the next section, in which requirements can be generalized and implemented in the VR demonstrator.

RQ1: Requirement: Simulation environment

A simulation environment should be created to enable developers to evaluate their design in this process. This supports possible improvements to the machines.

RQ 2: Requirement: Training environment

A training environment must be created so that skills can be further developed and trained. This is mainly for the service organization to train service on new products. However, new employees from both organizations can also be trained accordingly.

The demonstrator therefore aims an interactive VR simulation for the visualization of maintenance work in order to make work processes and conditions tangible and to train interdisciplinary skills. This is intended to digitize and make the cross-organizational exchange of knowledge between maintenance personnel and designers comprehensible.

From the combination of these arguments the problem definition can be derived as follows. The two areas of construction and maintenance are not yet sufficiently coordinated. Consequently machines are developed, which are not optimally maintainable.

3.3 Design & Development

Access to the VR demonstrator is guaranteed by the consumer technology HTC Vive Pro Eye and the Unreal Engine. The goal is to provide a solution that can be used in numerous situations and different scenarios. Thus, an abstraction step of the constructures is performed before implementation. This will give us a more flexible approach that will be easy to use. Subsequently, with the help of the "Business Process Model and Notation" (BPMN) models are created, which will reproduce the recorded

process steps in general and clearly for the software developer.

The maintenance relevant process steps should be presented as detailed as necessary but as general as possible. Not every specific detail needs to be simulated and interactively designed in VR. This will allow the transfer to different machine types.

The simulation of machines designed in CAD will allow the developer a high degree of creativity. A pipeline is being developed for this purpose. This pipeline will convert CAD design files that are exported as STEP files to VR. The interaction with these transformed objects, however, is not possible. However, the designer can determine which CAD objects are replaced by interactive VR objects. This follows a previously defined naming scheme and enables the execution of simulated maintenance work on these VR objects.

3.4 Demonstration

The VR demonstrator is created as a hardware-software demonstrator. This development is done in an agile way to be able to flexibly take up the results of the parallel running evaluation. The VR demonstrator represents the technical solution comprehensively and focuses on the immersion of the user and the experience within the VR environment.

In the future, implementation strategies will be developed to anchor the VR demonstrators in the organizations. These implementation strategies determine how the processes are designed, how the target groups are integrated for productive use and how accompanying organizational measures (e.g. guidelines and workshops) are implemented. Based on these strategies, the VR demonstrator is implemented in the organizations in the form of a pilot project. The experience gained will be analysed and used to further develop the VR demonstators.

4 Future steps

4.1 Evaluation

The VR demonstrator will be continuously evaluated. In the future, this evaluation will take place with regard to the extent to which the respective status of the demonstrator can be used for competence development and for teaching in work processes along the hybrid value chain. In addition, it is examined whether the solution offers significant added value for networked working. A field evaluation with users will be planned. This will take place in the form of several field studies with the demonstrator. In the run-up to the demonstrator, individual aspects (e.g. VR simulation environments, learning/ supportability or applicability) will be evaluated in laboratory studies.

In the context of the quality assurance of the VR demonstrator, a formative evaluation is aimed at, which continuously checks technological (e.g. usability tests) and technical aspects (e.g. process step integration). Furthermore, the development will be discussed and reflected upon, e.g. in workshops with all project participants. The goal will be an iterative development with the results of the evaluation.

4.2 Communication

Project coordination is carried out continuously. At the beginning of each month there is a digital jour fixe using a web conference system with all persons and organizations involved in the project. The project organization is agile in order to incorporate possible feedback into the development of the demonstrator in a timely manner. The immediate communication via the web conference system ensures that the defined goals are achieved on time and according to plan. Problems can be detected early on due to the continuous exchange of information. A continuous exchange between the project partners helps to ensure the consolidation of the project results. All these measures are then additionally supported by regular physical project meetings. This exchange will form the

basis for future communication about the project and its results.

5 Discussion

This research deals with the development of a VR demonstrator for the simulation of partly dangerous maintenance procedures. Inspired by developmental research method a problem-oriented research design was presented (Peffers et al., 2007). The requirements were then derived on the basis of the problems identified. On this basis, qualitative interviews were conducted with the organizations' practitioners. Afterwards, the resulting findings were evaluated by all participants in a workshop and learning scenarios were developed to solve the original problem of the lack of competence development along the hybrid value chain.

In the demonstration phase the VR demonstrator will be presented and explained to the employees of the organizations. Special attention is paid to the applicability, to the respective configuration and the simulation of the workflows. Subsequently, further feedback and evaluation phases are planned in the form of further workshops, qualitative interviews and experiments. According to the results obtained, the unique simulation properties of VR lead to an improvement in product quality as well as to an improvement in service quality. Especially, the pipeline management, which allows an immediate simulation of the CAD data, was highlighted as a key feature and an important contribution.

Another decisive factor is the hardware used. In the field of VR Head Mounted Displays the best possible immersion is a big discussion. The reduction of the CAD data with simultaneous possibility of interactive with components was solved by a hybrid approach.

As with any practice-oriented research study, there are some limitations: First, the empirical basis for the developed VR demonstrator is based only on the development and service scenario. In order to overcome this limitation, it is intended to transfer the VR demonstrator to further use cases. The research have verified the benefit of the VR demonstrator in a service scenario and development scenarios in two organizations. According to the interviews it is helpful to transfer at least the service scenario to other organizations. This way, the employees of other service organizations, who also maintain the machines of the organization, could be addressed. Second, the evaluation so far is limited, because on the one hand the project is not finished yet. On the other hand the participants of the evaluation could only test the VR demonstrator for a short period of time. Therefore this study intends to carry out a long-term evaluation in the future in order to gain a detailed insight into the effects of the demonstrator on the work of the employees.

Nevertheless, a demonstrator should be created that can be used in practice for the development of many products.

This paper has also introduced technology in an organizational context, which helps employees in the service sector to get to know their work processes better. This helps organizations keep pace with the competition by better training employees and saving resources. In the field of research, this study have made a scientific contribution to the design science research methodology for information systems research (Peffers et al., 2007)

Guidelines could be developed which could be extended to other use cases through extension, application and evaluation. The collected knowledge can further help to understand how VR can be integrated into the industrial context. It can be determined which concrete artifacts a VR needs to be better designed to support employees in their work processes.

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Part C: Perspectives on Technology Use and Adoption

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To Resist, or not to Resist, that is the Question: On the Status Quo Bias of Public Sector Employees When Dealing with Technology

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Abstract. Technological innovations and new ways of working became the daily routine in German administrations at the municipal, the state and the federal level. Technology use among their employees is an essential aspect of mastering the digital transformation in the public sector. The employees' status quo bias, however, profoundly influences their perception and behaviour in technology-related settings. The critical role of cognitive biases is recognised in many disciplines, including sociology, psychology, and marketing. Against this background, the objective of our work is to expand existing acceptance models with the aspect of bounded rationality and apply them to employees in the public sector. This allows us to gain theoretical insights concerning the resistance of using technology in this domain. As technology becomes ever more ubiquitous in times of the coronavirus pandemic, and as the performance and well-being of public sector employees is more and more important to the administrative board members, including the status quo bias perspective when dealing with technology use presents increasing theoretical and practical importance.

Keywords: Technology Acceptance, Status Quo Bias, Bounded Rationality, Public Administration, Cognition

1 Introduction

Demographic changes pressingly affect the public sector (Müller et al., 2011). In order to both fulfil legal requirements and growing expectations of citizens, to provide appropriate services and to have a productive and satisfied staff, public administrations are trying to use the advantages of digitization to make their routines more effective and efficient (Liu & Yuan, 2015; Räckers et al., 2017). Nevertheless, the implementation and the use of technologies need comprehensive change management on both a technical and organizational level (Ben Rehouma, 2018).

The employees' acceptance and motivation to use technologies is crucial in this regard. Their soft skills such as openness and willingness to learn become increasingly relevant for the success of the digital transformation in the public sector (Ogonek et al., 2016). However, many employees are sceptical or afraid to lose control and fear to be replaced due to not mastering the new tools. Their reluctance leads to the fact that the potential of available

technologies are not fully used, which in turn results in many disadvantages such as time or financial costs (Kim & Kankanhalli, 2009). Facing limited resources, it is all the more necessary to understand how to reduce the staff's resistance and how to promote the skills needed for dealing with the ongoing changes.

Technology acceptance and the intention to use information technology (IT) is at the core of Information Systems (IS) research (Venkatesh & Davis, 2000). Although there are many theories that aim to understand these concepts (e.g., TAM), the Status Quo Bias (SQB) perspective by Kim and Kankanhalli (2009) offers fruitful added value, because it integrates existing literature and well-known concepts from the bounded rationality paradigm in order to explain user resistance prior to the implementation of a technology. The traditional models did great effort to show which factors influence acceptance and use, but fail to account for the cognitive biases of the users. We want to find out which variables are responsible for the frequent technology resistance of employees within the public sector and to provide necessary skills to master the digital transformation in this domain. Against this background, we want to answer the following research questions (RQs): **RQ1:** *Which variables influence user resistance towards technologies in the public sector?* **RQ2:** *How can we reduce the user resistance towards technologies of public sector employees?*

We aim for obtaining a more holistic view of technology acceptance and use behaviour of public administration staff by reflecting on the cognitive biases they face. The goal of our work is to advance theory and to derive useful recommendations for action. The structure of this paper is as follows: Section 2 provides the theoretical background. In Section 3, we establish our hypotheses, naming the considered variables and boundary conditions. Section 4 presents the research design and methodology. Finally, section 5 contains a conclusion of our work, also pointing on promising avenues for future research.

2 Theoretical Background

Previous literature indicated different models for describing technology acceptance, from which one is used predominantly: the Technology Acceptance Model (TAM) (Davis, 1989). In contrast to this model supposing the rational decision-making of the user, the SQB perspective describes people's tendency to maintain original habits instead of accepting new circumstances by accounting for their cognitive biases (Samuelson & Zeckhauser, 1988). Next, we describe these models in more detail.

Technology Acceptance Model

In order to explain the decision-making behaviour of public administration staff when using IT, we base our considerations on fundamental technology acceptance research. Davis pivotal work in the area of technology acceptance derived two significant antecedent of technology use: perceived usefulness and perceived ease of use (Davis, 1989). *Perceived usefulness* is "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320). A technology of high perceived usefulness has an increased use-performance-relationship. *Perceived ease of use*, in contrast, is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). Davis' approach aims to provide a general explanation of the determinants of technology acceptance that can explain the users' behaviour across a wide range of end-user technologies and user populations, while being parsimonious and theoretically justified (Davis et al., 1989). Moreover, it seeks to provide a basis for understanding the influence of external factors on internal beliefs, attitudes and intentions. By doing this, the model is useful for predicting, as well as for explaining why a particular technology might be unacceptable to then conclude appropriate corrective action.

Status Quo Bias Perspective

Cognitive biases happen when "human cognition reliably produces representations that are systematically distorted compared to some aspect of […] reality" (Haselton et al., 2015, p. 968). People are unconsciously influenced in their decision-making and judgement. In this respect, the „status quo bias [SQB] theory aims to explain people's preference for maintaining their current status or situation" (Kim & Kankanhalli, 2009, p. 569). Based on this approach, we seek to explain the resistance of public administration staff.

Samuelson and Zeckhauser (1988) pioneered to describe why people tend to stick to present conditions instead of adapting to new circumstances. Their SQB perspective is divided into three categories: rational decision making, cognitive misperceptions and psychological commitment. As technology users often resist, even if technology use offers rational advantages, biases are present. Consequently, it is considered beneficial to adapt the original approach from psychology to the IS domain in general and to the public administration staff in specific. At the core of our investigation are the antecedents of user resistance, which is described "as opposition of a user to change associated with a new IS implementation" (Kim & Kankanhalli, 2009, p. 568).

Rational decision-making deals with the cost and benefit comparison of change (i.e., transition costs and uncertainty costs). Transition costs happen by adapting a new system and can occur during or after a change to a new system (Kim & Kankanhalli, 2009). Uncertainty costs occur by switching to a new system and cause that users feel unsure or anxious about the upcoming results of that action. They automatically remember similar past situations, and in most cases, make the same decisions as before, because they do not want do take any risks (Kim & Kankanhalli, 2009).

Cognitive misperception describes the perceived loss of change. One phenomena of this category is loss aversion, which results in the fact that people assess even small changes from a current situation as higher than they are (Kim & Kankanhalli, 2009, p. 569), because they tend to weigh losses more heavily than gains (Kahneman & Tversky, 1979). Another type of this category is the anchoring effect, which refers to the existing propensities and expectations of a person, which serve as the basis for an initial value to evaluate the change in the context of the initial state (Tversky & Kahneman, 1974).

The third category is called *psychological commitment*, which consists of sunk costs, social norms and efforts to feel in control (Samuelson & Zeckhauser, 1988). Sunk costs refer to the value of earlier commitments, which lead to a reluctance to switch to a new alternative, such as skills that are related to the previous way of working and are lost when switching to a new system. Social norms refer to the prevailing norms towards changing the way of work, which can influence the SQB of an individual, such as a colleague's opinion that may influence the will to accept or resist a system. Efforts to feel in control arise from the desire to control or determine situations. This can lead to a distortion in the status quo of the person, because she or he does not want to lose control over a known system or working method (Kim & Kankanhalli, 2009). In general, psychological commitments deal with the users worry about wrong decisions they cannot reverse (Lee & Joshi, 2017).

Having presented the three categories of the SQB perspective, it becomes clear that Kim and Kankanhalli developed a framework that includes the theoretical foundation of the original technology acceptance literature and additional concepts from the bounded rationality paradigm in order to explain user resistance. The authors aimed at understanding how the implementation of technologies is assessed and acknowledged that beliefs generate a favourable or unfavourable attitude towards behaviour (Kim & Kankanhalli, 2009).

3 Research Model

Now, the main categories of the SQB are closely examined and explained in the context of user resistance to technologies among public sector employees. The theoretically developed model is based on the SQB perspectives by Kim and Kankanhalli (2009) and was adapted after conducting qualitative interviews with five public sector employees in order to refine the framework. At the moment, it includes four categories and is presented in Figure 1.

The first category is *rational decision-making* and contains four variables: uncertainty costs, transition costs, perceived value and switching benefits. In addition to uncertainty costs and transition costs, we extended the model by two further variables: Perceived value indicates whether the usefulness of the new system is considered high or low. Switching benefits name the perceived resource plus (e.g., time, money) of switching to a new system.

The second category is about *cognitive misperception*. It refers to perceived losses of a change and consists of loss aversion and the anchoring effect. Loss aversion influences the perceived value of using a new system, because it acknowledges that people weigh losses greater than gains (Tversky & Kahneman, 1974). Next, the anchoring effect points at the expectation of using a new system when considering past experiences and thresholds.

The third category, *psychological commitment*, is built of sunk costs, efforts to feel in control and social norms. We deviate from Kim and Kankanhalli by moving social norms in another category to measure it more appropriately within context of the public sector.

The fourth category is about *organizational and social influences* and contains four variables. As mentioned above, we placed the variable social norms in this category and divided it into two separate parts: colleague opinion and management as role model. The aim is to account for hierarchy in the public sector and to separately measure the influence of the opinion of direct colleagues as well as of higher-ranking employees such as managers. We also added two other variables this category: organizational support and perceived value for others. The first one is about the organization providing assistance in times of change. The second one refers to the estimated benefit for others, in our case, for citizens.

We also consider several control variables, i.e., self-efficiency, habit of using technologies at work, personnel responsibility, ranking within the organization, duration of work and other demographic data (e.g., age and gender). These variables may influence user resistance in a way that people might have a greater technical affinity and are more open minded for the new. However, correlations could also go in the other direction and make employees more afraid than necessary, when it comes to digitization and technology use, due to general scepticism.

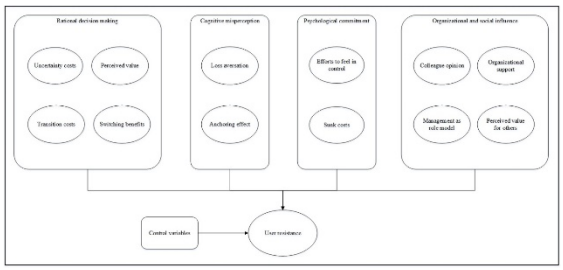

Figure 1. Research Model

4 Hypotheses Development

Based on the theoretical foundation, we derive twelve hypotheses. Pointing at the first category ('Organizational and social influence'), colleague opinion is defined as the perception that colleagues support the changes associated with a new IS implementation. We suggest that a positive opinion towards using a technology by colleagues on the same organizational level reduces user resistance, because employees directly see improvement and chances.

H1: Positive colleague opinion has a negative effect on user resistance.

Organizational support for change often appears in the form of training and resources. This can

reduce the perceived difficulty of adapting to new systems. Consequently, the higher the organizational support for change, the lower the transitions costs in terms of time and effort to learn the new way of working. Therefore, organizational support for change is expected to reduce user resistance.

H2: Organizational support has a negative effect on user resistance.

Higher ranking employees, such as the mayor herself or himself, can act as role model and thereby influence the staff. For this reason, there is a high probability that the resistance to a new system decreases if the top management uses it itself.

H3: Management acting as role model has a negative effect on user resistance.

The perceived value for others (e.g., citizens) reflects the result of one's work. On this basis, it can be suggested that the resistance to use a new technology decreases when the employee notices the positive effects, this change has on others. If, for example, the citizens' satisfaction with public sector services increases after forms of eGovernment have been introduced, the staff directly sees the benefit and is probably more inclined to embrace eGovernment technology than before.

H4: A high perceived value for others has a negative effect on user resistance.

Considering the second category ('Psychological commitment'), it is important to both ensure that employees remain in control of their own actions and to make the investments they already made (i.e. their sunk costs) as appropriate as possible, among other things, by keeping new investments to a minimum. This is achieved, for example, by making technology very easy to use to make employees quickly feel able to use and understand it. Furthermore, the learning effort and the hurdle to further training remain low.

H5: A low effort to feel in control has a negative effect on user resistance.

H6: A low perception of sunk costs has a negative effect on user resistance.

Keeping in mind the third category ('Cognitive misperception'), it is worth considering that people always remember past situations and base their current actions on them. Thus, it is important to set the anchors present in the anchoring effect are not too negative for the employees. For example, it is useful to remind them of training courses that they have enjoyed. It is also possible to familiarize them with systems that are very easy to use and then remind them that they have already mastered the introduction of a technology very well. This also reduces the fear of making mistakes and losing a lot by introducing a technology, i.e., their loss aversion.

H7: A low loss aversion has a negative effect on user resistance.

H8: Setting pleasant anchors has a negative effect on user resistance.

Finally, addressing the last category ('Rational decision making'), switching benefits refer to the perceived value of changing to a new system. Noticing one's higher performance, among other beneficial outcomes, could increase the perceived value of a change and decrease the resistance to using a new system.

H9: Switching benefits have a negative effect on user resistance.

As mentioned before, perceived value describes whether the perceived benefit of a new system is higher than its costs. If the perceived value of a new system is low, it is more likely that resistance to that system occur. The fact that the benefit of using a system must be higher than the cost, stresses the need to find ways to increase the overall perceived value of technological change. This also means that the transition and uncertainty costs that changes entail are kept as low as possible.

H10: Perceived value has a negative effect on user resistance.

H11: Low uncertainty costs have a negative effect on user resistance.

H12: Low transitions costs have a negative effect on user resistance.

5 Research Design, Methodology, and Outlook

In cooperation with a small municipality in Germany, we plan to conduct a three-stage mixed method study. In this study, we seek to combine the traditional acceptance model with the SQB perspective. To this day, we already conducted a qualitative pre-study with a focus group to derive a scenario of a typical technology implementation and to identify missing independent variables in our theoretical framework. The implementation of a document management system was selected as a typical case. Moreover, we ran a pilot survey with a small set of employees (n=5) to further revise the questionnaire. However, it should not remain unmentioned that our work is not yet complete. In the next phase, the survey will be sent to all employees of our partner municipality in an online format. The following step will be comprehensive data cleansing and analysis. Based on this, we hope to identify significant correlation and cause-effect relationships and to better understand the resistance of new technologies in the workplace by public administrations staff. The goal is to further develop our theoretical model. This potentially leads to a more condensed model and motivates future investigations of the identified factors. The overall aim is to contribute a theoretical added value on how to integrate different models stemming from the rational choice or bounded rationality paradigm as well as a practical surplus by providing recommendations for action.

In sum, our study is intended to provide a guide how public sector employees can adapt to changes caused by the digital transformation. In this context, we aim to derive promising strategies on how to counteract their scepticism and anxiety when dealing with novel processes and technologies. The results can easily be scaled in order to transfer knowledge to other municipalities and organizations.

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From Technology Adoption to Organizational Resilience: A Current Research Perspective

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Abstract. Digitalization is an ever-increasing phenomenon and is being focused in all prominent research communities around the world. When it comes to businesses, the concept of digitalization can have its far-reaching impacts due to the diverseness of business and distinctiveness of their capabilities. Small and medium enterprises (SMEs) are of dire importance in this research arena, due to their immense share in global economy and organizational characteristics. The concept of digitalization needs special attention for these business specimens. Technology adoption models need to be built which can transcend the utility of digitalization and digital technologies in SMEs. We propose a hypothetical technology adoption model for increasing the digital maturity in small and medium business organizations and further proposing that matured digitalization will lead to centralized business continuity infrastructure which can boost the organizational resilience.

Keywords: Digitalization, Organizational Resilience, Technology Adoption, Small and Medium Enterprises, SMEs

1 Introduction

Technological innovation has revolutionized the ways of how business organizations operate, with the fast pace of digitalization (Remfert & Stockhinger, 2018) and 4th industrial revolution or digital transformation (Schwab, 2017). More relationships are being formed and maintained online than ever before, including supplier-purchaser relationships and even collaboration between employees of the same company (Herbsleb et al., 2000). If digitalization is considered in the perspective of digital technologies than having a digital interconnection, having access to static and dynamic information and ways of collaborative work articulation using digital technologies (or Information and Communication Technologies further ICT) can be seen within the ever spreading digitalization sphere. In the wake of digital transformation, the adoption and accumulation of different digital technologies like SMACIT (social, mobile, analytics, cloud and Internet of things) technologies (Sebastian et al., 2017) are an effective digital business strategy (Bharadwaj et al., 2013). ICT adoption seems to have a positive effect on productivity, directly as well as indirectly, depending on the sectors and have great potential to support a sustainable development (Ollo-Lopez & Aramendia-Muneta, 2012). Furthermore, the

use of electronic commerce (e-commerce) and social media have significantly cut down on the physical transportation involved in sending mail, banking, advertising and buying goods (Manochehri et al., 2012).

Within the taxonomy of organizations ranging from meso, micro, small and medium enterprises (SMEs) to big companies, SMEs have been discovered to be a key driver for a country's economic growth and crucial for a progressive economy (European Commission, 2017), thus the backbone of Europe's economy. They represent 99% of all businesses in the European Union (EU). In the past five years, they have created around 85% of new jobs and provided two-thirds of the total private sector employment in the EU. The European Commission considers SMEs and entrepreneurship as a key to ensuring economic growth, innovation, job creation, and social integration in the EU. SME is defined as an organization with less than 250 employees and less than a (or equal to) 50 million turnover (European Commission, 2017). SMEs are often global leaders within their numerous niche markets (so-called 'hidden champions' by Simon (1996)) (Ludwig et al., 2018).

The course of action adopted by many SMEs tend to keep them in their 'comfort zones' and hence hinders with the adoption of new technological advancements. This is compounded by the fact that employees make demands on technologies that they know from private use (Richter et al., 2017), which often leads to unauthorized use of private IT, also called "Shadow IT" (Steinhueser et al., 2017). The dawn of 4th industrial revolution and the vastly transforming technological paradigm poses multiple threats to the traditional ways of work routines and without taking up the correct measure, SMEs tend to lose the competitive advantage within their numerous niche markets (Remfert & Stockhinger, 2018). Sullivan-Taylor & Branicki (2011) explored the SMEs in Great Britain and found that with the ever-increasing threat of natural and man-made disasters, SMEs do not hold the resources and technical systems often equated with resilience capabilities. And despite being agile and flexible, SMEs may be need to become more strategic and driven in their approach to manage the threat and actuality of extreme events. SMEs are marginalized in the adoption of technologies and innovations in the realms of digitalization and even if they essentialize the use of digital technologies to some extent, they lack the level of maturity to reach the designated levels of digitalization, which can pave the path towards a resilient organization.

This research presents a hypothetical model for gauging the digitalization in SMEs via the usage of digital technologies. The technology adoption model lays the foundation of a benchmark roadmap for achieving the highest level of digital interconnectedness which will not only enable the SMEs to successfully transform into digital workplaces, but will also make them continuous and prepared for disasters and emergency situations. This work in progress starts off with the concise related work section for usage of digital technologies as an aspect of digital transformation, also specific to SMEs. Then, we demonstrate the usage of different digital technologies by SMEs in Germany. Later, we exploit the different categories of digitalization in SMEs for the development of the hypothetical technology adoption model for digital interconnectedness. Lastly, an ideological infrastructure for business continuity in SMEs is presented which can be realized as an epicentre of digitalization leading to a resilient organization.

2 Motivation and Literature Review

Ackerman et al. (2007) argue that for users to adopt technology they must both understand its capabilities and have scaffolding mechanisms for collectively discovering, structuring, iterating, and promulgating practices that enable the technology to become a 'resource'. This also holds true for the adoption of digital technologies for achieving digitalization in

SMEs. Blatz et al. (2018) illustrated that the strategy, leadership, company culture and organization are the most weighted factors influencing the adoption of digital technologies in an organization. The extent to which an organization is digitalized is purely subjective and unstandardized.

An evident decrease in the use of communication channels like emails, pagers etc. sets a clear indication towards the adoption of easy, simple and effective digital mediums in business organizations (Muller et al., 2003). Attention should be paid to training, team working, communications and change management. Digital interconnection channels can improve internal business interconnection and social networking within an organization, hence establishing cooperative work environment in SMEs. Involvement of people from all focus areas of business, such as production, sales, suppliers, vendors, customers and customers to-be is a strategic priority for achieving business excellence. SMEs use many different technologies but fail to fully adjust themselves in the evolving digitalization & digital transformation paradigms, thus lacking the ability to achieve business excellence (Tarutė & Gatautis, 2014; Manochehri et al., 2012; Schwab, 2017). Limited funds, lack of internal and external skills, expensive technological transition and poor infrastructure are the key barriers in the adoption of digital technologies (Ongori, 2009). Acar et. al. (2005) explained that SMEs are exceptional in nature and the two main reasons for the underutilization of ICT are the lack of staff with appropriate skills and the satisfaction with existing methods.

Digitalization spans throughout an organization, it specifies the abilities of a firm including employees' collaboration, work articulation and coordination among themselves, between departments and with their suppliers and customers (Nguyen, 2009). Digital technologies are required to manage coordinated task execution, effective communication, implementation of business processes, employee-management relationship, b2b & b2c cooperation and much more. It stretches from the use of emails as the traditional way of asynchronous coordination to the more sophisticated e-commerce and digital workplace solutions for extensive cooperation and collaboration throughout a business organisation and beyond (partners, suppliers, retailers, distributers and customers). More than half of the companies (53.30%) have an internet connection and e-mailing appears to be the most common application with 47.14% using it (Nguyen, 2009). At one extreme, increased email overload, however, was associated with reduced coordination effectiveness, so it is not simply a negative psychological phenomenon, but also has negative organizational consequences (Dabbish & Kraut, 2006). Meanwhile, at the other, the e-commerce adoption literature implies that firms need to be internally and externally ready and active all the time to ensure their digital presence (Tan et al., 2007). An organization's internal readiness can be summarized as the availability of financial and technological resources, the top management's enthusiasm to adopt e-commerce, technology infrastructure, compatibility of the firm, as well as culture and values (DeBerry-Spence et al., 2008).

Digital technologies also comprise ICT groupware solutions such as messengers & chatbots like WhatsApp, Telegram, Slack etc., and elaborate communication channels such as the web-based and desktop project management solutions like Trello, Asana etc. The ASPect Project Case illustrates the benefits of ICT adoption leading to innovation in Dutch SMEs (Boekhoudt & Van der Stappen, 2004). While examining the use of group communication technologies like messengers or instant messaging (IM) platforms, Muller et. al. (2003) found that in the teams of all organizations they surveyed, getting a quick response and a better connection were the two main reasons to use instant messaging (IM) for formal and informal interconnection within an organization. Rathore and Ilavarasan (2014) provide the evidence on

the potential benefit of the applicability of mobile digital technologies such as smartphone applications and social media for internal and external business outreach in Indian SMEs. They also urge SMEs to be 'cloud ready' and use non-proprietary and commonly available technologies for gaining the competitive advantage. Young et. al. (2019) argue for the efficacy of immersive telepresence in order to ordain remote collaboration in contrast to desktop-based telepresence technologies. Cloud computing and Platform as a Service will be the future solution for Indonesian SMEs (Wiradinata, 2016). The potential benefits in the adoption of e-commerce in the SMEs of Ghana (Iddris, 2012) and Indonesia (Aidah et al., 2017) present promising transformation opportunities towards matured digitalization.

1) The scope of our investigation is a utopian perspective for the usage of digital technologies for digitalization in SMEs, due to three main reasons: as per the observations made in the secondary data from the ZEW Mannheim Innovation Panel, there are substantial number of SMEs using different technologies
2) The digital technologies in the scope of this investigation are basically technological genres not bounding the SMEs to adopt a specific artefact or tool for achieving a certain level in digital interconnection for example if 'informal team communication' is a genre than all the artefacts like Telegram, Slack, WhatsApp, Viber, Skype can be instances to achieve informal team communication
3) Industry has to 'turn to practise' of the digital technologies for achieving interconnectedness to accomplish digital transition leading to digital transformation (Lewkowicz & Liron, 2019).

3 Methodology: Digital Technologies in SMEs

In order to identify the current usage of digital technologies and to establish a notion of future usage of digital technologies for digitalization, we used the data from the Mannheim Innovation Panel (MIP) survey for a short descriptive analysis. The MIP data comes from the Leibniz Centre for European Economic Research (Leibniz-Zentrum für Europäische Wirtschaftsforschung - ZEW). The MIP survey is an annual survey of the innovation activities of German organizations from 21 industrial sectors (both service and manufacturing industries). The data have been collected annually since 1993 through a regular distribution of questionnaires among the German firms. The MIP dataset is structured as a panel dataset. Each annual wave of the MIP survey comprises, in addition to the basic organizational attributes of the respondent organization, questions pertaining to their innovation activities (e.g., new products, new services, improved products, improved services), innovation related expenditures (e.g., research and development investments, skilled labor) and the economic implications of innovations (e.g., revenue, productivity). Moreover, new questions are included in the annual survey to address the growing demand of researchers in relation to emerging topics.

The MIP survey of 2016 was used for the desired descriptive analysis, as it contained the information regarding the usage of digital technologies in German organizations not just at the time of survey but also the expected usage in 5 years time. More specifically, the respondents were asked the following additional question: "To what extent does your enterprise currently use the following applications of digitalisation in different business function areas, and will the usage of these application likely increase, decrease or stay the same in the next three to five years?". Each respondent was asked to respond on a categorical scale; for the current usage (high,

medium, low, no) and for the future usage in the next 3-5 years (increase, stay the same, decrease).

The questionnaire for the MIP 2016 dataset has classified 11 digital technologies (D1-D11) for an organization which were further categorized in four interrelated groups in the dataset. The dataset consists of the detailed information about the responses of 4,685 German firms. Since the focus of our research is on SMES, we have used the European Commission's definition of an SME and, in addition to discarding missing and incomplete information, we have removed large firms (with more than 250 employees), and micro firms (less than 5 employees) from the sample. After cleaning and restructuring of the dataset, we have obtained a sample of 2,266 German SMEs. The segregation of the commonly used digital technologies can be seen in Table 1.

Technologies for inter- and intra-digital interconnection of an organization
D1: Digital interconnection within production / provision of services D2: Digital interconnection between production / service provision and logistics D3: Digital interconnection with customers D4. Digital interconnection with suppliers
Technologies for internal collaboration, cooperation & communication
D5: Teleworking D6: Software-based communication (Skype etc.) D7: Intranet-based platforms (Wikis etc.)
Technologies for external digital interconnection
D8: E-Commerce D9: Social media (Facebook, Twitter etc.)
Technologies for information processing and business analytics
D10: Cloud computing / cloud applications D11: Big data analysis

Table 4. Digital technologies as per MIP survey

The descriptive analysis for the current and future usage of these digital technologies can be seen in Table 2 (p.6). An important aspect to note in the segregation of digital technologies is the aspect of generalization. The business organizations were asked about the technological genre without explicating an artefact. That gave freedom to the participants to provide open-ended information about digital technologies which fall in the categories of digital technologies. The descriptive analysis shows that the SMEs used the digital technologies from a low to a mediocre extent. The fascinating aspect supporting and motivating the development of our hypothetical technology adoption model is the future usage of digital technologies. The increase in the usage of technologies within a set of 2,266 SMEs is representative and encouraging enough to pave the path towards the standardization of technology adoption in SMEs.

4 Results: Technology Adoption Model

After the identification of technological genres through data from MIP survey and establishing the notion of the usage of digital technologies, we have developed the hypothetical technology adoption model, as shown in Figure 1. This model can also be seen as a maturity model as it intends to mature the digitalization process in SMEs by gradual technology adoption. Generic model development framework proposed by de Bruin et al. (2005) is used for the development of the hypothetical model. The agenda of the whole process is to enable comparative benchmarking for digitalization in SMEs, in order to guide the digital transformation by gradually increasing the technology adoption in SMEs. The second stage of the generic framework is to develop a design or architecture of the desired model. A common design principle is to represent maturity as a number of cumulative stages where higher stages build on the requirements of lower stages. The five stages of the hypothetical model have been proposed after rigorous brain storming sessions and review of literature mentioned in the previous sections.

We utilized mind mapping as a tool to analyze the digital technologies under the lens of different stages of maturity. This iterative process yielded five maturity levels of

technology adoption. Each maturity level is an augmentation of the preceding level and is well defined with respect to the domain of digitalization. In order to populate the five levels, we used the different identified sets of digital interconnection technologies examined in the aforemnetioned MIP survey. These stages not only depict the evolution of digitalization but also the actors around these technological measures. These levels further bespeak the process and organizational attributes acquired during the adoption and maturation of digitalization.

Digital Technologies	Number (N) of SMEs	Current usage of digital technologies (0(No) – 3 (High))		Future usage of digital technologies (1(decrease) – 3(increase)	
	N	Mean	SD	Mean	SD
Production / service provision					
D1: Digital interconnection within production / provision of services	2,266	1.522948	1.027074	2.436893	0.5136012
D2: Digital interconnection between production / service provision and logistics	2,266	1.284201	1.037695	2.367608	0.5133031
D3: Digital interconnection with customers	2,266	1.421889	0.9648741	2.492498	0.517411
D4: Digital interconnection with suppliers	2,266	1.244042	0.9235799	2.400265	0.5138092
Internal organization / communication					
D5: Teleworking	2,266	0.690644	0.8648499	2.15887	0.4279458
D6: Software-based communication (Skype etc.)	2,266	0.790821	0.8921658	2.248455	0.4778168
D7: Intranet-based platforms (Wikis etc.)	2,266	0.768314	0.9147709	2.237864	0.4785885
Sales / external communication					
D8: E-Commerce	2,266	0.705649	0.8634516	2.266549	0.5012146
D9: Social media (Facebook, Twitter etc.)	2,266	0.61827	0.811834	2.237864	0.5002389
Information processing					
D10: Cloud computing / cloud applications	2,266	0.602383	0.8242321	2.266108	0.4992432
D11: Big data analysis	2,266	0.413945	0.698064	2.181818	0.4618281

Table 2. Description of Digital technologies and Usage within SMEs

The ‘Ad-hoc’ level represents an enterprise with a 1-1 communication on a need-to-do basis (only if necessary without formal standard procedure) with traditional means like email etc. Digital interconnectedness is mostly proactive and decentralized and dependent on individual initiatives and skills. The SMEs at ‘Exploratory’ level becomes more procedural or procedure-oriented in the adoption of digital technologies. Teams initiate formal and informal group communication and coordination. Organization formalizes internal digital interconnectivity between management & employees, through exploratory channels and mediums. Employees are trained for better coordination and collaboration. The next maturity level is ‘Planned’, when the enterprise is mature enough after exploration of digital technologies that it starts focusing on digitalization in a planned manner to achieve ‘coordinated actions’ and knowledge flow. Internal connectivity is enhanced by spreading the digitalization to all the organizational stakeholders e.g. management, production (employees), suppliers, logistics, customers etc. Organization takes reactive measure to reach to potential customers through passive digital channels.

After a planned approach towards digitalization, the business organization starts moving towards a ‘Managed’ digitalization strategy. This strategy is centralized and an accustomed practise within an organization.

The organization takes initiatives towards secure custom software-based communication and coordination over an intranet platform. Alternatives for coordinated workspace option are adapted and the organization establishes active external digital interconnectivity channels with potential customers. Finally, the organization reaches the 'Evolved' state in digitalization. Digital connectivity is optimized and well maintained by the elaborate application of e-commerce and digital workplace practices. The evolved state demonstrates a highly interconnected and a resilient SME. Such an organization is expected to have procedures and technological infrastructures in place for emergency situations as well as a normal day in business.

5 Discussion

This exploratory paper proposes an evolutionary maturity model, starting off with low digital interconnectivity and basic level technologies which can be termed as essentials as used in organizations to some extent. Then slowly progressing towards more sophisticated technologies for higher digital interconnectedness and hence, higher maturity. It is important to note that according to the evolutionary approach, maturity in digitalization in SMEs is achieved through the gradual increase in the usage of digital technologies. The organizations at higher maturity levels have all the technologies in some form which are presented in lower maturity levels. The so called 'Evolved' level i.e. the highest level of the technology adoption model is of keen importance for further discussion and future research.

It sets a milestone on the roadmap of digitalization, in terms of absolute digital interconnectedness, abundance of skilled labor to use these technologies for cooperation and collaboration, network of enterprises, and critical communication channels. It is the best-case scenario for an organization because it has methods for unforeseen situations, a community to depend upon, labor with cooperative abilities, and a digital infrastructure for both good and inconvenient times (i.e. a crisis).

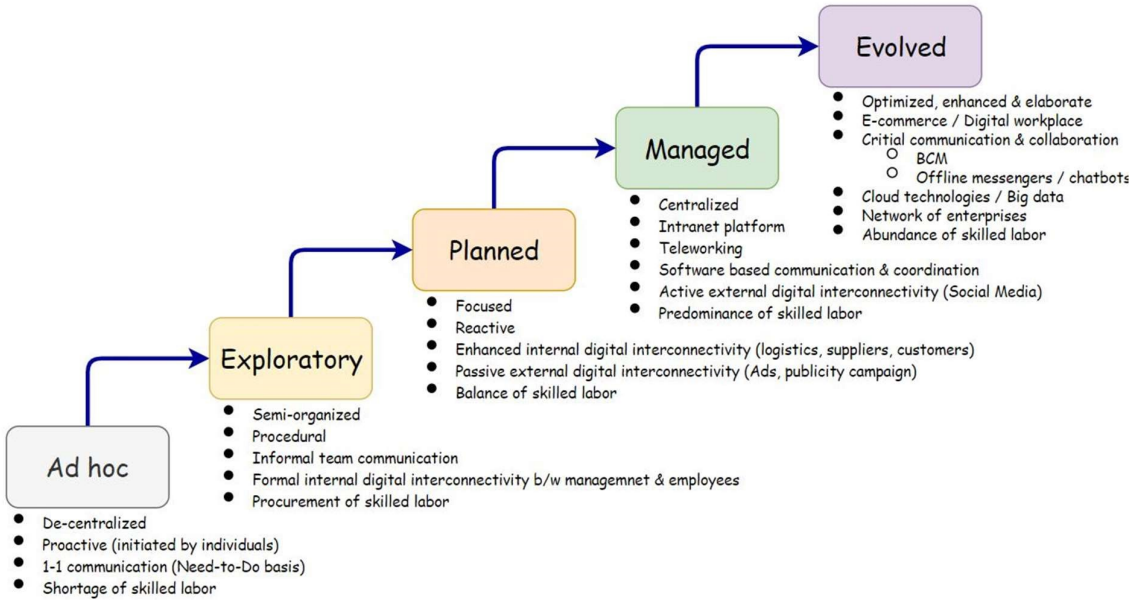

Figure 1. The technology adoption model with the staircase maturity representation

The purpose of this hypothetical model is to encourage SMEs to consider these recommendations as a path to follow and strive for a maturity which enables them to be resilient in times of crisis. It is unrealistic and impractical to expect resilient SMEs and business continuity without even considering the preconditions of digitalization. An organization without a procedural technological infrastructure for communication and coordination in normal routine is more likely to lack critical infrastructure for emergency situations.

The presented model is novel for taking the critical scenarios into consideration, as a pinnacle of digitalization. The highest level of maturity enlists some features related to critical communication infrastructures and crisis management. This model doesn't have concrete information about the technological solutions required to fulfil the criteria and this leaves a lot of flexibility for SMEs to take up the solutions as per their specific requirements. Even though we have information about cloud technologies and big data usage which somehow provide the features related to data safety and interconnectivity in crisis, there can be other, more sophisticated solutions which build on these advanced technologies targeting the specific context of an organization. The use of these solutions (like BCM, disaster preparedness apps) in the evolved maturity state is more of an optimistic proposition for an organization and an open topic of research to date. We recognize it as a limitation but not a big hurdle to affect the utility of our mode. Further limitations include the influence of different independent variables on technology adoption in SMEs which is also unexplored and can be explored in future research. This study also opens many other prospects for future considerations. We would like to investigate the impact of digitalization maturity from individual organizational perspective and also the relation between revenue and digital maturity. The concreteness of business continuity and how it evolves internally within an organization is also a factor to be investigated. The scarcity of available data for the usage of critical infrastructures and business continuity solutions form a strong foundation for surveys, interviews and qualitative and quantitative empirical studies and R&D in crisis management.

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The Sweet Escape – A Research Agenda on Escapism in Information Systems Research

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Abstract. Escapism is often defined as temporally getting away from unpleasant situations or thoughts. Since technology creates new opportunities to escape from something unpleasant, the interest in studying escapism has recently increased in information system (IS) research. However, despite growing interest on escapism, research is still in its very beginning stages. To explore IS phenomena more comprehensively this paper proposes a research agenda that highlights current shortcomings and the need to address these shortcomings. Thus, this paper provides a point of departure for future research on escapism and encourages IS-research to further investigate the effects of escapism in IS-related settings.

Keywords: Escapism, Escaping, Information System Research, Research Agenda, Technology Use

1 Introduction

Popular forms of daily escaping-activities are watching TV, listening to music, reading books or online gaming (Warmelink et al., 2009). They all allow us to go from somewhere we don't want to be, to somewhere we do (Evans, 2002). Since Germans spend an average of 236 minutes per day watching TV, 36 minutes per day listening to music, 26 minutes reading books and 30 minutes per day with gaming (SevenOne Media 2019), they are escaping a lot of their waking time (Warmelink et al., 2009).

Literature defines escapism as a way to escape from unpleasant realities or distract attention from problems (Li et al. 2013; Young et al. 2017). Since escapism is often referred as unhealthy, it is considered as negative, both within academic and popular views (Calleja, 2010; Warmelink et al., 2009). More current literature shows that escapism also includes positive aspects. This literature suggests that escaping provides a way for transient mental retreat (Siricharoen, 2019; Vorderer et al., 2004) and therefore can be stress relieving (Kuo et al., 2016; Warmelink et al., 2009). Evans (2002, p. 75) notes that "as escapism appears to be a natural mechanism, the mind must have need for it".

Technology offers new opportunities to escape (Siricharoen, 2019) and therefore allows us to escape from situations one could not escape from without it (Cahir & Werner, 2013). For example, using the mobile phone to play online games allows to escape from unpleasant situations such as being preoccupied with unpleasant thoughts. Since escaping from specific situations is a natural and omnipresent behaviour, IS researcher started to acknowledge the ubiquity and relevance of escapism and

demonstrated that escapism can influence acceptance, adoption and use behaviour of technology (Hartl & Berger, 2017; Holsapple & Wu, 2007; Li et al., 2013; Yee, 2006).

Despite the first valuable efforts to show that the concept of escapism is relevant in various domains in the context of IS, research is still in very beginning stages. This paper aims to develop a research agenda that seeks to shed further light on current shortcomings and the need to address them. Therefore, this work provides a point of departure for further research and encourages IS-research to investigate the effects of escapism in IS-related settings including technology acceptance, adoption and use behaviour in more detail.

In order to address the objective, the subsequent sections are structured as follows: In section two, existing research is briefly described. In section three, the research agenda is proposed. In section four, contributions of this research are highlighted.

2 Theoretical Background

There is no established definition of escapism so far (Evans, 2002; Kuo et al., 2016). Escapism is oftentimes defined as a behaviour to escape or distract oneself from something unpleasant (Hirschman, 1983; Young et al., 2017). Escapism is also understood as "get [temporally] away from it all", often involving an element of "pretend" (Huizinga 1949 as cited in Mathwick et al. 2001, p. 44). More current literature describes escapism as the need to avoid thinking about real life problems (Xu et al., 2012; Yee, 2006). Since there is no established definition, we refer to Yee (2006), Xu et al. (2012) and Young et al. (2017) and define escapism as a behaviour that occurs when individuals use information technology (IT) to temporarily escape from uninteresting or unpleasant aspects of reality and instead think about or do more pleasant things.

There are two motivation types to escape from reality: Cause-based and effect-based motivations (Warmelink et al., 2009). Caused-based motivations serve the purpose of negating an element in life (Warmelink et al., 2009). For example people escape due to their desire to get out of their routine or demands of the day to day world (Li et al., 2013; Wu & Wang, 2011) or to release stress (Kuo et al., 2016). Another cause-based motivation is to distract attention from real-life problems or avoid thinking about real-life problems (Hartl & Berger, 2017; Korkeila & Hamari, 2018; Weiss, 2011; Yee, 2006). Effect-based escapism (e.g., pleasure seeking or imagination conjuring) allows people to transcend reality by pursing an activity or fantasy (Warmelink et al., 2009).

Escapism is often used in a highly negative discourse (Warmelink et al., 2009) because it is considered to be a contributing factor for alcohol and substance abuse (Aldwin & Revenson, 1987; Chambers et al., 2005). Moreover, it has been associated with unhappiness, isolation, high anxiety levels, dissatisfaction, and addiction (Hirschman, 1983; Meier et al., 2018; Warmelink et al., 2009; Xu et al., 2012). More recent literature demonstrates that escapism also provides a way for mental relaxation and therefore can release stress (Kuo et al., 2016) and improve mood (Hoffmann et al., 2017). Evan (2002, p. 55) notes that escapism is often seen as a "voluntary way of getting to the part of their brain that is most happy, pleased and relaxed, whether through activity or by not doing nothing". In line with this positive understanding, escapism can lead to positive feelings and amusement (Jung & Kang, 2009).

Escapism can be operationalized as a state and trait because it is both a personality trait to tend to engage escape from something unpleasant, but also a pattern of escaping in respect to a given situation (Hartl & Berger, 2017; Warmelink et al., 2009).

Existing literature distinguishes four types of escaping-activities (Evans, 2002; Kuo et al., 2016; Siricharoen, 2019; Warmelink et al., 2009): Evasive escape-activities comprise all

activities to avoid another activity e.g., walking out of an argument. Active escaping-activities e.g., playing computer games, describe a participative or collaborative form of escapism requiring an actual input from the escapist. In contrast, passive escaping-activities denote a non-participative form of escapism i.e., the escapist acts as passive observers from a third-person perspective. The fourth form are extreme escape-activities: They denote a problematic form of escapism as they encompass dangerous and challenging activities e.g., excessive computer gaming.

Escaping-activities can significantly differ in their duration. The time horizon can range from the short-term postponement of an action to the medium-term postponement or avoidance of feelings to the lifelong suppression of certain questions (Kohler, 2014).

Emerging technologies allow us to withdraw problems from reality into the virtual world and therefore offer new opportunities to escape (Siricharoen 2019). For example, virtual reality (VR) glasses induce presence, a sense of being in another environment, and therefore offer escapists an enjoyable experience by immersing them in an arguably more favourable virtual environment (Hartl & Berger, 2017). Thus, IS-research has recently acknowledged the relevance of escapism and first attempts have been made to demonstrate that escapism can influence acceptance, adoption and use behaviour of technology. For example, Holsapple and Wu (2007) identified escapism as an emotional factor underlying an individual's intention to accept virtual worlds. Hartl and Berger (2017) showed that escapism as a distinctive personal trait determines the adoption of VR glasses. Parker and Plank (2000) found that escaping predicted internet usage. Li et al. (2013) demonstrated that escapism strengthens influence on an individual's continuous intention to use social network games. Figure 1 summarizes the different dimensions of escapism embedded in a technology related-context.

Despite the valuable first efforts to investigate escapism in IS context, research is still in it very beginning stages.

Therefore, in order to assist future research in this field, a research agenda is developed, highlighting current shortcomings and the need to address these shortcomings.

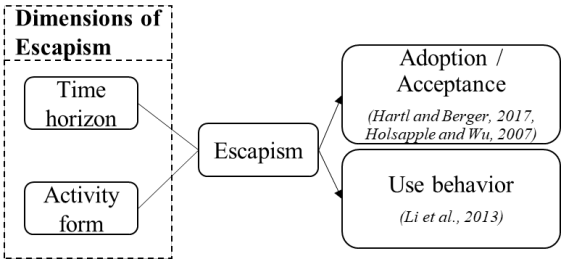

Figure 1. Escapism in technology related context

3 Research Agenda

Although IS-research is increasingly considering escapism, there is a lack of conceptual clarity. For example Young et al. (2017, p. 25) define escapism as "a behaviour employed to distract oneself from real life problems". In turn Thiruchselvam et al. (2011, p. 84) define distraction as a state of "deploying attention away from the emotionally salient aspects of an emotion-eliciting event". Since both definitions imply that attention is diverted away from something unpleasant, the definitions overlap and it remains unclear how escapism and distraction can be separated. Furthermore, Evans (2002) defines procrastination as an unhealthy form of escapism. In contrast Meier et al. (2018) define escapism as "a dysfunctional avoidance coping response to negative life circumstances" while the authors define procrastination as "a self-regulatory failure rooted in low self-control". Therefore, it remains unclear if procrastination is an unhealthy form of escapism or if escapism and procrastination are two distinct concepts.

The lack of conceptual clarity impedes theory development. Therefore, it is important to separate escapism from related constructs including distraction and procrastination. Consequently, we raise the following research question:

Question 1: What are the idiosyncratic characteristics of escapism and how can escapism be separated from related constructs including distraction and procrastination?

With an increasing body of knowledge, two dimensions of escapism have been identified: the escaping-activity form (e.g., evasive, active, passive, extreme) and the time horizon (e.g., short-, middle-, long-term). Since, research on escapism is still at its beginning stages, there could be more dimensions that are not considered yet. For example, there could be a differentiation between hedonic and utilitarian escaping-activities. Most escaping-activities listed in literature are hedonic, for example gaming or watching TV. However, Evans (2002) gave the example that escaping could also mean to do more pleasant tasks before pressing ones, which could be considered as an utilitarian escaping-activity. Moreover, there is a lack of literature investigating if individuals are always aware of their escaping behaviour. Investigating and understanding the diversity of escapism is an important step to study the effects of escapism on IS-related phenomena in more detail. In this context we raise the following research question:

Question 2: Are there any additional dimensions of escapism?

IS research has started to acknowledge the mentioned dimensions. For example Kuo et al. (2016) developed a conceptual framework for active escapism, which comprises antecedents, processes and consequences of active escapism in the context of video game consumption. Warmelink et al. (2009) developed a framework that assigns cause-based and effect-based escaping motivations to the different escaping-activities. Despite these valuable first efforts to understand the different escaping dimensions, there is a lack of literature, investigating the influence of the different dimensions on IS-related phenomena. To fill this gap is an important step to a better understanding of acceptance, adoption and use behaviour. Against this background, we raise the following research question:

Question 3: How do the different dimensions influence IS-related phenomena including acceptance, adoption and use behaviour?

First valuable attempts have been made to measure escapism. For example Lee et al. (2004) developed a measurement instrument to study escapism in the domain of tourism. Chung et al. (2012) adopted and refined this measurement instrument by adding the item "Getting a change from a busy job." Xu et al. (2012) developed a measurement instrument to investigate escapism as functional need that drives online game playing and addiction. Hoffmann et al. (2017) introduced the concept of escapist Facebook use and developed a measurement instrument to investigate escaping-behaviour while using Facebook.

However, an established measurement instrument that accounts for the richness of escapism is still missing so far. Existing scales are limited in terms of addressing the stability (i.e., state or trait) and the different dimensions (i.e., escaping-activity and time horizon). These shortcomings are critical, as valid and reliable measurement instruments are a prerequisite for theorizing and theory development (Gregor, 2006, 2014; MacKenzie et al., 2011; Moore & Benbasat, 1991). A valid and reliable measurement instrument encourages IS-research to further investigate the effects of escapism in IS-related settings. In this context we raise the following research question:

Question 4: How should existing instruments be modified to consider the different dimensions of escapism?

4 Contribution

This work aimed to advance research on escapism by developing a research agenda highlighting current shortcomings and the need to address these shortcomings. Since escapism is a natural and omnipresent behaviour, our

research will contribute to theory and practice alike:

From a theoretical perspective, future research on escapism in technology-related settings can benefit from this research agenda as a point of departure. The investigation of escapism is an important step to a more holistic understanding of IS-related phenomena in various domains, such as use behaviour, acceptance, and adoption research. Moreover, research on important job-outcomes (e.g., productivity) can benefit from investigating escapism in more detail.

Investigating escapism is also beneficial from a practical perspective. It provides important insights in the usefulness of escaping-activities. Therefore, it contributes to a better understanding, how organisations should take escapism into consideration when designing future workplaces. To be more precisely, research on escapism extends knowledge how to give more room for escapes, for example by including hedonic aspects in employees working environment.

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Part D: Future Perspectives

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New Perspectives on Statistical Data Analysis: Challenges and Possibilities of Digitalization for Hypothesis Testing in Quantitative Research

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Abstract. p-values, the 'gold standard' of statistical validity are not as reliable as many scientists assume. In the last decade, severe problems have been observed regarding the validity of highly reputable research. Additionally, the growing availability of big data challenges the design and statistical analysis of studies and experiments across science. Therefore, it is more important than ever to make the best use of available computational tools, software and possibilities digitalization offers to improve the validity of research results. In this paper, we focus on an essential procedure often carried out in quantitative research, which is directly related to the experienced problems: Statistical hypothesis testing. First, we show that the traditional way of hypothesis testing has severe logical problems. Second, it is shown that due to the increasing availability of computational resources, highly sophisticated methods from the area of computational statistics - namely Bayesian data analysis - can complement and even replace traditional hypothesis testing. Third, we highlight how digitalization helps in making these technologies available to a vast range of researchers in the form of the novel and free software package JASP. Together, this paper shows that considering a change in perspective on statistical data analysis, in particular on hypothesis testing, provides the possibility to improve the transparency and reliability of research in the medical, social and natural sciences.

Keywords: Data Analysis, Mathematical Psychology, Hypothesis Testing, Bayesian Statistics, Statistical Inference

1 Introduction

In 2005, epidemiologist John P. Ioannidis of Stanford University suggested that most published research findings are false (Ioannidis, 2005). Since then, countless papers have explored the situation many scientists face for nearly two decades now (Begley & Ioannidis, 2015; McElreath & Smaldino, 2015). These include problems with the replication of existing study results and the validity of a vast amount of highly reputable research. Entitled as the replication crisis (Baker & Penny, 2016), a string of publications detailing how these problems form has forced scientists to reconsider how research results are evaluated

(Colquhoun, 2017; Ioannidis, 2016). In particular, statistical data analysis has been identified as one major piece in the big puzzle of the replication crisis, causing even scientists with the best intentions into trouble. A large part of the observed problems was already attributed to the "surprisingly slippery nature of the p-value, which is neither as reliable nor as objective as most scientists assume", as (Nuzzo, 2014) notes. While the p-value is often used to identify significant research findings and study results in quantitative research, in a large number of cases it produces false-positive results, that is, states an effect if none is present. This fact is highly problematic, as reducing the number of false-positive results is one of the biggest necessities of contemporary science (McElreath & Smaldino, 2015). The situation even led the American Statistical Association (ASA) to release an official statement in 2016, which stressed that *"by itself, a p-value does not provide a good measure of evidence regarding a model or hypothesis."* (American Statistical Association, 2016). What is more, in light of the problems the ASA recommended to supplement or even replace p-values with other approaches which *"emphasize estimation over testing such as (...) Bayesian methods"* (American Statistical Association, 2016) and "alternative measures of evidence such as likelihood ratios or Bayes factors" (American Statistical Association, 2016). Many approaches have been proposed to counteract the problems identified in p-values (Wasserstein et al., 2019). The ideas range from methodological shifts (Kruschke & Liddell, 2018) to simpler options as applying stricter standards for declaring statistical significance (Benjamin et al., 2018). While the ongoing problems are far from being solved, through the debate about statistical significance an increasing number of scientists has become aware that it is necessary to change current practices of data analysis, especially hypothesis testing (McElreath, 2020; Wasserstein et al., 2019). In this paper, we show how Bayesian data analysis can replace traditional p-values, leading to more reliable conclusions. Also, we showcase how digitalization helps to foster transparent and reproducible research by presenting the statistical software JASP. JASP has been developed at the University of Amsterdam and implements a vast range of highly-sophisticated Bayesian statistical methods, making it an attractive candidate to improve the reproducibility of research.

2 Null hypothesis significance testing

In this section, we briefly review the theory behind p-values, which are part of *null hypothesis significance testing* (NHST). Also, we highlight some of the logical fallacies of NHST.

2.1 A brief introduction to NHST

The traditional way of hypothesis testing goes back to the early 20th century. In the approach of (Neyman & Pearson, 1936), who published their highly influential theory in the 1930s, the general format is to test a *null hypothesis* H_0, which makes a statement about a parameter δ against the *alternative hypothesis* H_1. After conducting the experiment and calculating the hypothesis test, the experimenter either has to accept or reject H_0. Due to the nomenclature one often calls this procedure *null hypothesis significance testing* (NHST). A *hypothesis test* can now simply be interpreted as a rule stating for which observed sample values the decision is made to reject H_0. The values for which H_0 will be rejected is called the *rejection region*. To construct a hypothesis test, the so-called *sampling statistic* of the quantity of interest, the parameter δ, is considered. For example, when comparing two normally distributed groups like a treatment and control group in a randomized controlled trial (RCT), often the quantity of interest is the difference in means $\mu_1 - \mu_2$ of both groups. The distribution of the differences in means $\mu_1 - \mu_2$ under the null hypothesis H_0 - that is, the sampling statistic - can be derived theoretically (Held & Sabanés Bové, 2014). After conducting the study and observing the quantity of interest, for example, $\mu_1 - \mu_2 = 3$,

the known distribution of $\mu_1 - \mu_2$ is used to determine how plausible it is to obtain a difference of $\mu_1 - \mu_2 = 3$ or even larger differences. Figure 1 visualizes NHST: On the x-axis, it shows the set of possible results, which in the above example are all possible values of $\mu_1 - \mu_2$. Based on theoretical results, the distribution of this quantity $\mu_1 - \mu_2$ under the

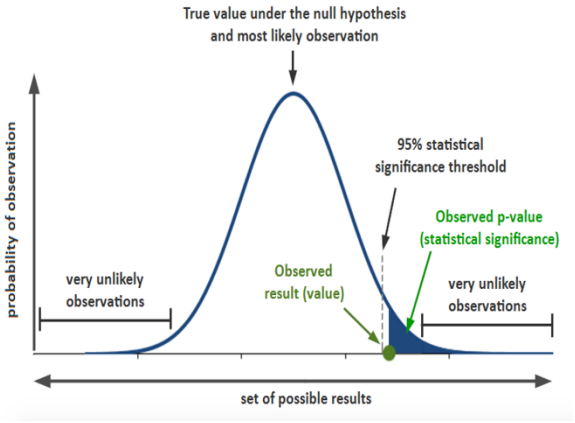

Figure 1. Null hypothesis significance testing

null hypothesis H_0 is well known, shown as the bell-shaped density in figure 1. Under H_0, it is quite unlikely to observe very small values or huge values. In the above example, when observing a result like $\mu_1 - \mu_2 = 3$, the idea of *statistical significance* is to calculate the probability of obtaining a difference equal to or more extreme than the difference observed. This probability is the coloured area right to the observed result in figure 1, and this is exactly the p-value often reported in quantitative research. If the p-value is small, it seems plausible to reject the null hypothesis, because observing such a large difference would be highly unlikely under H_0. *"The p-value is the probability, under the assumption of the null hypothesis H_0, to obtain a result equal to or more extreme than what was actually observed."* (Held & Sabanés Bové, 2014). Over time, the well known 95% statistical significance threshold has manifested itself in science, which was invented by (Fisher, 1925). The threshold is shown as the dashed vertical line in figure 1 and simply states that one should reject the null hypothesis H_0, whenever the p-value is smaller than 0.05. That means one rejects H_0 whenever one would observe a difference equal to the one observed or more extreme with 5% or less probability under the null hypothesis H_0. It is important to note that formally, a continuous quantification of the p-value when using the Neyman-Pearson theory is not allowed. The p-value can only be interpreted as a binary value for the decision against (if $p < 0.05$) or for H_0 (if $p \geq 0.05$).

In summary, frequentist hypothesis testing can be seen as a procedure targeted at the long-term type I error control.

2.2 Problems with NHST and p-values

NHST may seem reasonable at first. Nevertheless, there are some severe logical fallacies which we want to pinpoint here. These problems question the usefulness of NHST for practical research and call for other options. First, there are two types of errors which need to be considered: If the null hypothesis H_0 is true, but the hypothesis test incorrectly decides to reject H_0, then the test has made a *type I error*. If the null hypothesis H_0 is false, but the hypothesis test incorrectly accepts H_0, then the test has made a *type II error*. Table 1 gives an overview:

		Decision	
		Accept H_0	Reject H_0
Truth	H_0	Correct decision	Type I error
	H_1	Type II error	Correct decision

Table 1. Type I and II errors in hypothesis tests

Formally, every method of statistical testing can make these two types of errors. Nevertheless, NHST was developed to control the type I error while simultaneously minimizing the type II error (Neyman & Pearson, 1936).

2.3 Type I error control is not always appropriate and is not bullet-proof

The preference for type I error control is highly questionable in applied research. Consider a diagnostic test for a disease which uses a blood

sample to calculate the concentration of specific antibodies. Suppose one knows the number of antibodies follows a particular distribution in healthy individuals. Suppose also, that very large (or small) values which pass the 95% significance threshold indicate the presence of an autoimmune disease. When applying NHST and testing patients, the testing procedure will minimize the type I error. A type I error happens if a patient is told that she has the disease, but the patient is healthy. The consequence of a type I error is mild: Further diagnostics will show that the result was a false-positive one, and the caused costs are small. Consider now a type II error: A patient who has the disease will be sent home with a false-negative result. The condition will progress until the patient makes a second test and is diagnosed and treated correctly. The damage done is considerable: The disease has progressed, causing subsequent treatments to be more expensive next to the fact that the patient suffers unnecessarily. The example shows that type II error control is preferable to type I error control in some prevalent settings, making the usefulness of NHST questionable.

Additionally, countless papers have demonstrated that the type I error control guaranteed by NHST is often not attained. This leads to an uncomfortable situation in which a long-term type I error rate of 5%, in reality, equals a skyrocketing 36% false-positive rate (Colquhoun, 2014).

2.4 Falsification or confirmation?

The second problem of NHST is rooted in the philosophy of science itself. Due to space limitations, we cannot offer a full account here. However, falsification only makes sense when the goal is to narrow down a substantial number of research hypotheses. In other cases, researchers are more interested in *confirming* research hypotheses. Whether this refers to showing the effectiveness of a new drug, the efficacy of psychological interventions, or the improved performance of a new computational algorithm, scientists often need to confirm that a hypothesis is indeed correct (or at least the most suitable of a set of candidates). Additionally, scientists often need to rephrase research hypotheses to make them rejectable via falsification. For example, if the goal is to show that a drug for lowering blood pressure works, falsification forces scientists to formulate the hypothesis as $H_0: \mu_1 = \mu_2$, where μ_1 and μ_2 are the group means of the treatment and control group in the study. The actual goal is to *reject* this hypothesis H_0 to *confirm* that the drug works as expected. When discarding H_0, scientists still do not know how large the difference between μ_1 and μ_2 is, which is of much more interest than only stating that the difference is non-zero. After all, the difference could be negligibly small, although significant, making the research results scientifically less or even entirely irrelevant.

2.5 Dependence on the researcher's intentions

The third point is the most problematic: The findings and interpretation of NHST depend on the researcher's intentions. For example, it plays a crucial role if the number of participants in a study is fixed in advance, or if researchers sample participants until time or money runs out (Kruschke & Liddell, 2018). This situation causes unnecessary strain on financial and personal resources and makes the interpretation of results obtained via NHST difficult. When reporting such findings, researchers can unintendedly invalidate all their work by violating their sampling plan. Also, this opens the door to misuse of statistics by reporting a different sampling plan after the actual study has been conducted only to obtain a significant result. This practice is often called 'p-hacking' and is observed widely by now, which is worrisome (Ioannidis, 2019). Also, NHST violates the *likelihood principle* (LP), which is one of the most critical proven results in mathematical statistics (Berger & Wolpert, 1988).

3 Bayesian data analysis as an alternative

In this section, we review the theory behind Bayesian data analysis, which is an often proposed alternative to NHST. We highlight how some of the logical fallacies of NHST are avoided by considering the Bayesian approach.

3.1 Bayesian parameter estimation

It is helpful first to introduce the general idea behind Bayesian parameter estimation to get familiar with the conventional notation. Bayesian parameter estimation centres on the posterior distribution $p(\theta|x)$ of the unknown parameter θ after observing the experimental data x, which are assumed to follow a specific probability density $p(x|\theta)$, the likelihood function. The posterior distribution reflects the relative plausibility of different parameter values after the available prior knowledge $p(\theta)$ has been updated employing the data x via the likelihood function $p(x|\theta)$. Correctly, one starts by assigning the model parameters θ a prior distribution $p(\theta)$. The information in the observed data x is then used to update this prior information to the posterior distribution, where parameter values which yielded good predictions of the observed data x get a boost in plausibility.

$$p(\theta) \cdot p(x|\theta) \propto p(\theta|x) \quad (1)$$

The $\propto$ symbol in equation (1) means 'proportional to'. As modern sampling algorithms like Markov-Chain-Monte-Carlo (MCMC) which produce the posterior distribution numerically only need a function proportional to the posterior, it suffices to write the posterior in this way (McElreath, 2020). Analytic derivations of the posterior distribution are possible only for simple statistical models so that most realistic models require the use of MCMC algorithms (Robert & Casella, 2004). The posterior distribution can be summarized using point or interval estimates, like the posterior mean or median, or credible intervals. Credible intervals include a fixed percentage - for example, 95% - of the posteriors probability mass, and thereby make it possible to state in what range of parameter values the true parameter θ lies with a given probability. Note that this interpretation is often applied to frequentist confidence intervals, which is false.

3.2 Bayesian hypothesis testing

The structured approach to Bayesian hypothesis testing uses the Bayes factor (Jeffreys, 1961). The Bayes factor quantifies the relative predictive performance of two rival hypotheses. It can be interpreted as the degree to which the data demand a change in beliefs towards one of both hypotheses under consideration.

$$\frac{P(H_1)}{P(H_0)} \cdot \frac{p(x|H_1)}{p(x|H_0)} = \frac{P(H_1|x)}{P(H_0|x)} \quad (2)$$

The first term in equation (2) is the prior odds, which is the relative plausibility of the two hypotheses before observing any data. The second quantity is the Bayes factor $BF_{10}(x)$, which indicates the evidence provided by the data x observed. The third term, the posterior odds, indicates the relative plausibility of both hypotheses after having seen the data and is calculated as the product of the prior odds and the Bayes factor. The subscript in the Bayes factor $BF_{10}(x)$ indicates which hypothesis is supported by the observed data: $BF_{10}(x)$ is the Bayes factor in favour of H_1, and $BF_{01}(x)$ is the Bayes factor in favour of H_0. Algebraic rearrangements show that $BF_{01}(x) = 1/BF_{10}(x)$. Large values of $BF_{10}(x)$ signal more support for H_1 and the Bayes factor ranges from zero to ∞. A Bayes factor of 1 indicates that H_0 and H_1 both predict the observed data x equally well.

4 An example of digitalization in statistical data analysis: JASP

In this section, we show how Bayesian data analysis can be conducted by using the open-source statistical software package JASP (JASP Team, 2019). Through the advancing

digitalization and availability of more powerful computing resources, Bayesian methods are available to researchers in the form of software like JASP today without the need to code complicated programming. We use an example from medical science to show that more valuable information is obtained when considering Bayesian hypothesis testing. Also, we show how the reporting of research results is digitalized and made more transparent through JASP. A typical question arising in medical research is used as a scaffold to showcase the usefulness of Bayesian hypothesis testing: Do two groups (pre-treatment, after-treatment) differ on an observed metric variable, and if so, how large is the effect size between both groups? Usually, NHST compares the means μ_1 and μ_2 of the same population at two different time points via Student's paired-samples t-test to reject the null hypothesis via the use of p-values (Kelter, 2020a).

4.1 A Bayesian paired-samples t-test

The dataset used is from (Moore et al., 2012) and provides the number of disruptive behaviours by dementia patients during two different phases of the lunar cycle. The hypothesis tested is H_0: "The average number of disruptive behaviours in patients with dementia does not differ between full moon and other days" against the alternative H_1 of a differing average number of disruptive behaviours.

	t	df	p	Mean Difference
Moon - other	6.452	14	< .001	2.433

Table 2. Paired-samples t-test results for the dementia dataset obtained from NHST

Table 2 shows the results of the paired-samples t-test, indicating with $p < .001$ that H_0 can be rejected. Note that this is not what researchers want to know: The desired answer is which hypothesis is more probable after observing the data, which is precisely quantified by the posterior odds $P(H_1|x)/P(H_0|x)$. Note also that the Bayes factor BF_{10} is a crucial ingredient in the posterior odds because the posterior odds are the product of the Bayes factor and the prior odds. A large BF_{10} therefore necessitates a change in beliefs towards H_1. Assumption checks include a Shapiro-Wilk test on normality, which is not significant at $p = .148$.

	BF_{10}	Error %
Moon - other	1521.058	5.014e-7

Table 3. Bayesian paired-samples t-test results for the dementia dataset

Now, the Bayesian paired-samples t-test shown in table 3 in contrast yields $BF_{10} = 1521.058$, indicating extreme evidence for H_1. JASP also produces a plot of the prior and posterior distribution of the effect size δ, which is of interest in most medical research settings. Figure 2 shows the prior and posterior

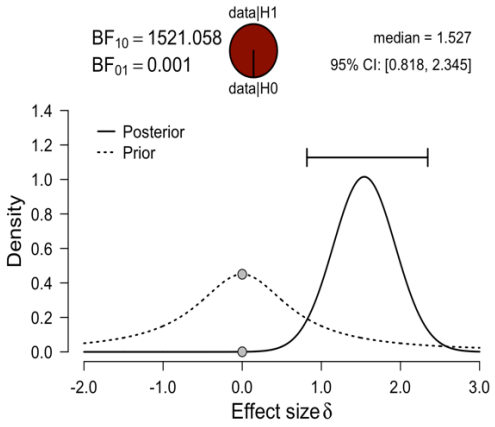

Figure 2. Bayesian data analysis of the dementia dataset of (Moore et al., 2012): Prior-posterior plot of the effect size

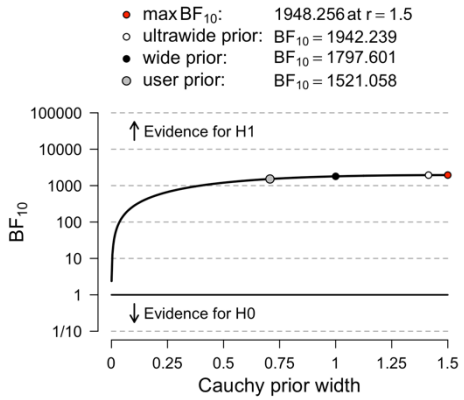

Figure 3. Bayesian data analysis of the dementia dataset of (Moore et al., 2012): Robustness analysis for the Bayes factor using varying Cauchy prior widths

plot of the effect size δ as well as the produced BF_{10}. The posterior of the effect size δ precisely estimates which effect size is the most probable after observing the data x. Note that the traditional paired-samples t-test did not yield any information about the effect size. Although it was significant, it did not state whether the observed effect is small, medium or large. The prior-posterior plot shows how the prior probability mass is reallocated to the posterior after observing the data and shows that with 95% probability, the true effect size δ is in $[0.818, 2.345]$ and the posterior median is 1.527, which indicates a large effect (Cohen, 1988). Another benefit is given by the robustness check shown in figure 3: Different prior distribution widths are used for the effect size δ and the Bayes factor BF_{10} is computed. Specifically, the prior width of the Cauchy prior $C(0, \gamma)$ on the effect size δ is increased gradually, showing how the prior shape influences the resulting Bayes factor BF_{10}. Figure 3 shows that even when changing the prior from the user prior, which equals a medium $C(0, \sqrt{2}/2)$ prior, to a wide $C(0,1)$ or even ultrawide $C(0, \sqrt{2})$ prior, the Bayes factor for H_1 stays above 1000. Therefore, the influence of the prior is negligible here, and only an insignificant amount of subjectivity goes into the analysis.

5 Discussion

The two examples above highlighted how Bayesian data analysis, including hypothesis testing via the Bayes factor, is efficiently conducted with JASP. Next to the ease-of-use, there are multiple benefits when considering the Bayesian way of hypothesis testing: (1) Testing statistical hypothesis with the Bayesian approach is following the likelihood principle. (2) It does not matter if one fixes the sample size of the study or experiment in advance or samples until time or money runs out. This fact is particularly important from a practical perspective. (3) In contrast to NHST, Bayesian data analysis can *confirm* research hypotheses under consideration. (4) The computational requirements to conduct Bayesian data analyses have been reduced significantly in the last years, making the approach available to a wide range of users. In combination with attractive software options like JASP, digitalization has therefore opened up new possibilities for researchers to improve the reliability and transparency of research results.

Still, there remain some challenges and limitations: The computational effort is larger when conducting Bayesian data analyses, which is caused by the substantial numerical calculations required for producing the posterior distribution. This is, in particular, true for complex and high-dimensional models (Kelter, 2020b). Still, for most standard models like linear regression or Student's two-sample t-test, there exist either analytic solutions or the computational effort is moderate, which leads to a seamless experience when using JASP. Note, that the flexibility of extending and adapting statistical models to one own's needs is also a big benefit of the Bayesian approach, and for a brief introduction, see (Kelter, 2020b) or (Kelter, 2020c; McElreath, 2020).

Another problem is concerned with keeping the influence of the prior selection as minimal as possible. While prior elicitation is an important topic in the literature (Held & Sabanés Bové,

2014; Kruschke & Liddell, 2018), the robustness checks available in JASP prevent cherry-picking the most suitable prior for obtaining the desired conclusions from raw research data.

Two aspects of particular importance not mentioned so far remain: First, all analyses conducted in JASP can be saved in a `.jasp` workflow file, which includes all data, analyses and results obtained. This possibility enables researchers from other laboratories to recreate reported analyses. Second, rich visualizations like the ones presented in the two examples above can easily be exported in JASP, which improves the digitalization of research. Third, JASP has built-in support for the Open Science Foundation (Open Science Foundation, 2020), which gives scientists the possibility to make their data, code and material available to others digitally.

6 Conclusion

Digitalization poses various challenges and opens new possibilities for scientists. In this paper, we focussed on the essential procedure of statistical hypothesis testing often carried out in quantitative research. First, we showed that the traditional way of hypothesis testing, NHST, has severe logical problems. Second, it was shown that due to the increasing availability of computational resources, Bayesian data analysis could complement and even replace NHST. Third, we highlighted how digitalization helps in incorporation of these methods into work. A brief presentation of the free statistical software JASP showed how easily Bayesian hypothesis testing is conducted, and a vast range of researchers should be able to benefit from considering the Bayesian approach. Interested readers should also take a look at the R software packages `bayest` (Kelter, 2019), which provides a convenient implementation of Bayesian t-tests in R. A review of how to improve the reproducibility in medical research by employing Bayesian posterior indices is given by (Kelter, 2020a). In summary, this paper highlighted the emerging possibilities digitalization has created for scientists from the medical, social and natural sciences when it comes to statistical hypothesis testing. Considering a change in perspective towards Bayesian hypothesis testing should, therefore, foster transparent, reproducible research across science.

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Reflective Practice in the Digital Age

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Abstract. The digital transformation, in the form of rapid changes, increasing uncertainties and unique situations, poses new challenges to all industries. As a result, there is tremendous use of new techniques and methodologies in order to enable "non-designer" to design. However, professionals of the "non-designers"-fields do not have the same requirements as designers have to do design thinking. With this short paper we aim to set out a preliminary conceptual framework of reflective practice in design context. To answer the question we go back to the roots of the actual design thinking discourse and set out a preliminary conceptual framework on basis of "Reflective Practitioner – How professionals think in action" as common denominator.

Keywords: Reflective Practice, Reflective Practitioner, Reflection in Action, Reflection on Action, Design Thinking

1 Introduction

The digital transformation, in the form of rapid changes, increasing uncertainties and unique situations, poses new challenges to all industries. One challenge is the demand of permanent innovation, which is not based on standard transactional business processes but on creating and designing new products, services and strategies which are based on creativity (Müller-Wienbergen et al., 2011; Matt et al., 2015; Hess et al., 2016).

As a result, there is tremendous use of new techniques and methodologies in order to enable "non-designer" to design (Brown, 2008; Brown and Katz, 2011). E.g. the "design thinking-methodology". The paradigm helps to create user-oriented services and products. There is also a stream on how to apply design thinking principles on strategies and organizations "design strategy" (Ignatius, 2015) and "change by design" (Brown and Katz, 2011), which is in line with the ideas of "managing as designing" (Boland and Collopy, 2004) and the idea of "science of the artificial" (Simon, 1967).

So, in order to progress we need to understand the commonalities and the differences in the underlying mechanisms of "how professionals think in action". This can be beneficial, because one critique is the practical orientation of common design thinking-approaches and that there is no explicit theory underlying in common design thinking-approaches (Schmiedgen et al., 2016). Is there a conceptual framework, which explains how professionals think in action? Such a framework can be helpful in order to identify possible connections and tailor-made applications of the design thinking method for different professions in practice.

To answer the question in further research, we go back to the roots of the actual design thinking discourse and set out a preliminary conceptual framework as common denominator. According to Johansson-Sköldberg et al. (2013) there is a discourse stream which is concerned with pragmatism epistemology what can help to gain insights for action, intervention and constructive knowledge (Goldkuhl, 2012). So Donald Schön – *Reflective Practitioner, How Professionals think in action* - is a first attempt of design discourse of designerly thinking in pragmatism paradigm (Johansson-Sköldberg et al., 2013).

With this short paper we aim to set out a preliminary conceptual framework of reflective practice in design context. Research question (RQ): *What is the framework of reflective practice in design context?* We want to derive the framework for ease of better understanding and ease of intervention in further research. To do so, we fist give an overview of Donald A. Schön's work *Reflective Practitioner - How Professionals Think in Action*. Secondly, we show the main dimensions of Reflection-in-Action in the case of an architect as an example for design context. Thirdly, we develop a framework. Fourthly, we make a proposal for further research.

2 Reflective Practice and the Ingredients

In order to understand the mechanism, we talk about Design Thinking – "the study of the cognitive processes that are manifested in design action" (Cross et al., 1992). With "Reflective Practitioner - How Professionals Think in Action", Schön has delivered a concept that describes situational thinking and action by practitioners (including architects). The concept consists of three parts (1) Knowing-in-Action (KiA), (2) Reflection-in-Action (RiA), (3) Reflection-on-Action (RoA). This serves as a basis for our framework of considerations.(Schön, 1983)[4]

2.1 Knowledge-in-Action

Knowledge – knowing-in-action – is of particular importance in practice for the following reasons. Professional practice has an element of repetition. The practitioner is often faced with repetitive tasks. The repetitions make his knowledge more and more specialized. This is accompanied by spontaneity, implicitness and automation. This helps to improve "processing economics" [ibid, p.60]. It also results in negative effects of knowing-in-action (described by Schön as knowing-in-practice), the so-called "overlearning" [ibid, p.60-61]. This manifest itself in an ever-increasing specialization, which can be avoided with the help of reflection-in-action in the following cases of overlearning: Blind spots: The high degree of specialization can result in a narrow view. This leads to the practitioner no longer perceiving problems outside his view as a problem. The practitioner no longer relates some phenomena to his area of responsibility. The practitioner loses sight of new phenomena that do not fit into his knowledge and ignores them. Fragmentation: Through specialization and "subcategorization", the big picture of a domain and its implicit knowledge can be lost. This relates to a specific knowledge about a problem, but interrelationship of phenomena (e.g. interdisciplinary problems) are ignored.

2.2 Reflection-in-Action

Although the practitioner in part consciously falls back on theories in everyday work, he is still dependent on his implicit perceptions, his ability to judge, and his skill [ibid, p.50]. His actions are often only unconsciously influenced by his "knowledge". In other places, however, his actions are shaped or enriched by conscious thinking and reflection. While he is acting, situations arise – sometimes ad hoc – in which he accesses his knowledge in the middle of the

[4] The following sources are listed as page numbers in the text for ease of reading.

action [ibid, p.50]. This is expressed exemplarily in questions such as: "What features do I notice when I recognize this thing? What are the criteria by which I make this judgment? What procedures am I enacting when I perform this skill? How am I framing the problem that I am trying to solve?"

This is the central process of reflection-in-action, the way in which practitioners deal with situations of uncertainty, instability, uniqueness, and value conflicts [ibid, p.50]. It is not conscious thinking but a kind of heuristic through which the knowledge of the practitioner (knowledge-in-action) is applied. Schön describes this process as reflective conversation with a unique and uncertain situation. Below, we introduce two aspects that have a direct impact on the phenomenon of reflection-in-action (Timing, Modes). Timing: Reflection-in-action is generally limited in time. There is only a certain amount of time during which you can make a difference by making a decision about the action. This has something to do with timing. The timing depends on the nature of the task and the situation at hand and is related to the speed of the activity. Speed and timing are a limiting element of the phenomenon. Different domains have found different ways to deal with it [ibid, p.62]. Modes: The goal of reflection is often completely different. Norms and expectations, behavioural patterns (influenced by implicit strategies and theories), impressions of the situation and/or his self-image are further factors influencing the way in which reflection-in-action manifests itself.

Process: (1) The problem space is defined. There is a kind of dead end in which one gets stuck and/or has an unsatisfactory result at hand. Every practitioner understands his task as unique and has to define the problem to be solved as the first step (framing – “F” in figure 1). It is not about replicating standard solutions [ibid, p.129]. (2) The problem space is then reset - the "reframing" (“RF” in figure 1). The focal point is shifted away from the problem to a different focus of the situation and its variables. This can result in new design possibilities. A practitioner succeeds in solving problems with a kind of craftsmanship. He succeeds in spontaneously and easily solving the difficulty and hopelessness posed by the complexity of a problem, which would unsettle a student or layperson [ibid, p.130]. (3) These will then be examined under the new problem space. It is a kind of experiment (“X” in figure 1) to enter into conversation with the situation. The practitioner succeeds in spontaneously comparing many solution variants and finding the best solution in his opinion without losing the flow [ibid, p.130].

Virtual Worlds: The experiments initially take place in a virtual world and serve as a context for the experiments [ibid, p.162]. The possibilities and abilities to influence virtual worlds are important characteristics of an architect and another facet of RiA [ibid, p.157]. Advantages of virtual worlds: The speed adjustment of RiA by means of drawing allows the architect to adjust the speed to his reflection. In this way, the architect can use it both ways in the design. On the one hand, he can draw a wall and test its effect on the ensemble much faster than in the real world. On the other hand, he can also pause to allow space for reflection-in-action in the flow of action [ibid, p.158]. Reversibility means that the practitioner can undo any "move". The quickly drawn idea of a wall can also be discarded just as quickly. This enables iterative loops and sequences of learning. And this without external restrictions, such as machine defects or similar environmental influences [ibid, p.158]. Restrictions: The repertoire of language makes it possible to study many phenomena. But it is also limited by the nature of graphic media. A good practitioner knows that drawings and representations cannot illustrate some things. This can only gain trust through experience [ibid, p.158]. The practitioner's experience influences the validity/reliability of virtual worlds. He must have wandered back and forth between building and drawing. An inexperienced architect therefore runs the risk

of not incorporating valid considerations into his reflection-in-action [ibid, p.159].

Experiment: The reflective conversation is a kind of experiment. However, it differs from the scientific experiment as we know it from research [ibid, p.143-146]. The biggest difference is objectivity with respect to the experiment [ibid, p.163]. The practitioner wants to influence the situation and therefore evaluates the situation according to the three features (1) solvability (Solvability), (2) coherence and intelligibility of the situation (Talk-back), (3) potential for further development of the situation and the conversation (Openness) [ibid, p.136]. Below, we will give a short introduction to these three features. Solvability: Even if an experiment of the practitioner cannot be evaluated on the basis of effectiveness, the practitioner must keep feasibility in mind when re-setting for "Reframing". An experienced practitioner always sets the new problem space in such a way that he feels he can solve the problem [ibid, p.134]. Talk-back: Talk-back with the situation arises and the practitioner thinks about it. Then the conversation is assessed by evaluating the direction in which the conversation is going. This judgement is at least partly based on his perception of coherence and congruence potentials, which he can realise through further investigation [ibid, p.135]. Openness: The openness of the architect is another dimension in the evaluation of the experiments. Within the framework of the experiment, the practitioner changes the problematic situation at hand without fully understanding the situation. In this way, he leaves room for something new and for unintended effects. These are then evaluated and answered with questions as to whether he likes it or not. In this way, new possibilities are discovered through conversation with the situation [ibid, p.134].

Experience: As the practitioner tries to solve a problem in a unique and unfamiliar situation, the question is how he succeeds in incorporating previous experiences. According to Schön, the practitioner brings in his experience in the form of a repertoire of examples, images, understandings and actions. When he faces a new situation with a problem to be solved, he sees both the unique and the equal (same and different features). He perceives the new problem as a variation on an old problem. On the other hand, there will also be moments in which he consciously compares the new situation with old situations and thus compares them in a reflective way [ibid, p.138-139]. Capability - "see-as" & "do-as": Decisive for the feeling of solving new problems where existing rules do not apply is the ability to see at unfamiliar situations as familiar ones and then judge them as if they were a familiar one. This enables practitioners to apply their experiences to new and unfamiliar cases. The quality of this ability – to use existing experiences in new, unique, and unknown situations – is reflected in the breadth and diversity of the repertoire. Through a feedback loop, each new experience will enrich the practitioner's repertoire [ibid, p.140].

Rigour: The necessary environmental conditions for a controlled experiment are very difficult or impossible to achieve in practice. In practice, the experiments are therefore rather nested [ibid, p.143]. In this sense, RiA is not an experiment. But, if one understands experiments more generically – "What if?" – then in practice there are different experiments that appear mixed up [ibid, p.145-146]. While research is only about pure understanding, the practitioner's overriding goal is to change the situation so that he likes it better than before and understanding the situation is only a means to an end [ibid, p.147]. The practitioner uses the hypothesis as a kind of imperative. He makes it "come true" and he tries to change the phenomenon he examines in the situation [ibid, p.149]. He thus breaks with all the rules that constitute a controlled experiment – objectivity and distance. While in research all biases (e.g. Hawthorne effect) should be eliminated [ibid, p.149], in practice they are more likely to be of use [ibid, p.63]. Transactional: Hypothesis testing in conversation with the situation is

neither self-fulfilling nor is it completely neutral. The practitioner's relationship with the situation is more transactional. He "manipulates" the situation but the situation, or rather the conversation with the situation, also influences him and his opinion and evaluation [ibid, p.150-151]. Stop: A crucial question is when to end the experiment. In research, the experiment is stopped as long as new theories can be introduced. In practice, it is about unintentionally finding something satisfying by (a) seeing something you like and (b) designing something that confers a new idea "as a whole" [ibid, p.150]. Appreciations: In practice, the primary goal is to generate an increase in value. Therefore, the practioner will stop as soon as a situation has been created that achieves an increase in value. Since there are other questions/issues regarding hypothesis testing that remain open and much can be investigated, hypothesis testing remains subordinate in practice/function [ibid, p.152].

Openenss: Conversely, practical experiments also have something that research experiments do not. The overriding intention is to change the situation. But, if the practitioner ignores the resistance against his intention to change, it becomes more of a self-fulfilling prophecy. Reflection on the situation is the goal [ibid, p.152].

Attidude: Objectivity towards the experiment influences the attitude towards the solution. How and where does the practitioner draw the boundaries between himself and the object/situation under investigation [ibid, p.163]? In contrast to the understanding of technical rationality, the practitioner becomes part of the situation and acts as a kind of agent/discoverer – which in turn influences the practitioners attitude. Thus, the attitude of the reflective practitioner is also shaped by a kind of "double vision" (two-headedness) [ibid, p.164]. On the one hand, it is about changing and adapting the situation but on the other hand it is also about keeping an openness for criticism of the situation. This is of course difficult with increasing commitment and energy invested into altering the situation.

3 The Dimensions of Reflection in Action in Design - Architect

3.1 Design Domains

The design domains with which the architect works are names of elements, properties, relationships, actions, norms for assessing problems and solutions, consequences and effects [ibid, p.95-96]. Thus, all consequences that are evaluated by the architect from possible "traits" in the design thinking process come from the design domains that are available to the architect (repertoir). During the evaluation, the design domains fulfil a multitude of functions that can be divided into three areas. (1) descriptive functions, (2) constructive functions, and (3) normative functions. The effects and consequences often extend over several design domains, which only strengthens their significance [ibid, p. 98].

References: It is important for the architect to recognize references during the design thinking process and to understand their specific meaning in the new context. The references serve as a tool to use visions in all design domains. The importance of the design domains as a limiting framework is also evident when references are used. Repertoire of design domains, prioritization: Through prioritization, the repertoire of design domains experiences a further restriction. It is easy to imagine that the number of design domains the architect pays attention to has a strong influence on the design thinking process. The relative frequency of design domains serves as an indicator of the architect's attention and prioritization [ibid, p. 98].

Variation in priorities: How the architect prioritizes the individual design domains in design thinking is not static. Rather, it must be imagined that the architect "serves" different design domains depending on the status of the project (e.g. nothing at hand, first idea of

cubatur, nearly fixed floorplan) [ibid, p.103]. The priorities in the different planning phases of the architect are normative. Depending on the planning phase, the priorities must be set differently. At the beginning of a project certain domains are more important than others (e.g. costs have to be estimated very roughly or cannot be considered at all, whereas the use of the property becomes a central question at an early stage) [ibid, p. 98]. Different styles and "schools" also result from the different prioritization of the design domains [ibid, p. 103].

The dimension of the design domains has an enormous influence on the proposals the architect develops in design thinking. The design domains have a quantative effect on the variety of possibilities and thus evaluated variants. Only what lies within the repertoire of the architect can be considered as a possible solution. In the end, however, this quantitative factor is reflected as a qualitative property of the architect.

"The practitioner has built up a repertoire of examples, images, understandings, and actions. Quist's repertoire ranges across the design domains. It includes sites he has seen, buildings he has known, design problems he has encountered, and solutions he has devised for them." [ibid, p. 138]

3.2 Implications

When you think about design thinking, you have to imagine the architect's thoughts as a whole network of possible "features". The consequences of each "move" have consequences for subsequent "moves". The web that the architect spins consists of further "features", consequences, effects, valuations. The effects can be partly expected from the architect and partly unexpected. From these unexpected effects, new possibilities arise for the overall idea [ibid, p. 94-95]. The design domains form the framework for action when the architect communicates the effects and their consequences in the form of words [ibid, p.95]. Communication often extends over several design domains [ibid, p.95]. The evaluation of the effects takes place three times. (1) With regard to expediency. (2) In relation to previous intentions. (3) Based on the expected impacts [ibid, p.101].

Impact on what: The architect evaluates the impact in a way that creates the opportunity for change. He always does this against the background of different "disciplines". In other words, in terms of the effects his "move" has on exposure. Or against the background of the building organisation and the walkways made possible by the current floor plan. In some cases, however, there are also effects on a larger scale, such as the effects of its "trains" on border distances or distances from other buildings. Perhaps, however, it is precisely the effects of changes in the floor plan (which entails an increase in the building volume) on the building alignment, i.e. the building cubator in relation to the surrounding buildings. On a smaller scale, however, the decisions also have an impact on hiding places or the accessibility of rooms, parts of buildings or entire complexes. Elsewhere, however, the architect also evaluates the effects of his "traits" on the handling of existing buildings (e.g. appreciative, ignoring, neutral) [ibid, p.101]. Complexity: Because the network of "trains" has many branches, it becomes a great challenge for the architect within the network to discover new ideas and good solutions for his problem. In addition, it is aggravating that one must not only consider and evaluate a decision for the moment, but also the consequences for possible later decisions with different meanings and effects [ibid, p.100]. The architect addresses the problem of complexity and uncertainty by fixing assumptions and variables from time to time, thus simplifying the growing system of variables and uncertainty. The architect must make a binding decision from time to time (initially) in order to allow further investigation and not allow the system to become too complicated [ibid, p.100].

3.3 Shifts in Stance

Another dimension that can be seen in the architect's RiA is the ability to change one's own attitude towards one's own design ideas several times (very simplified: good policeman, bad policeman).

Can/might or should/must happen: In some situation the architect can leave decisions open with a certain non-binding character. This is not possible elsewhere. Then things are more binding and the architect regards them as a necessary condition [ibid, p.101]. Some "moves" have to be implemented in order to create further possibilities. The cubature of a building is often bound to the site and the boundaries. Here some "moves" have to be made. If you build in an existing building, there are often "moves" that arise and must be made. For example, if you decide to maintain an old development (e.g. staircase). Then there are liabilities which have to be "worked out".

Focusing unit/whole: Another change in the attitude that the architect makes in design thinking is the change of perspective between the unit and the whole, i.e. the overall idea of the design. This is reflected in a change of attitude from participation on the one hand and demarcation on the other. Participation manifests itself in the form of active design of small elements of the design, while demarcation manifests itself in the form of observation of the overall situation [ibid, p.101-102].

Tentative adoption / eventual commitment: The complexity and uncertainty in the network of "trains" requires a further change of attitude on the part of the architect. That manifests itself on the one hand in a very hesitant assumption, which is quickly rejected again and questioned, and on the other hand in a final commitment towards a "train", which is binding for further investigation. Especially with a large number of iterations, this is extremely necessary to make the investigation manageable.

4 Framework

We can identify three dimensions that are critical to the way a practitioner works. Design domains decide the architect will include in his considerations. The Design Domains form the action framework for the solution attempts and have a "limiting" characteristic. Due to the repertoire of design domains with which the architect goes into conversation, the WHAT of the possible solution is decisive. The implications have an influence on HOW the architect deals with possible solutions in the decision tree. The Implications no longer ensure that something is taken into account or not, but much more in what quality the considerations are carried out.

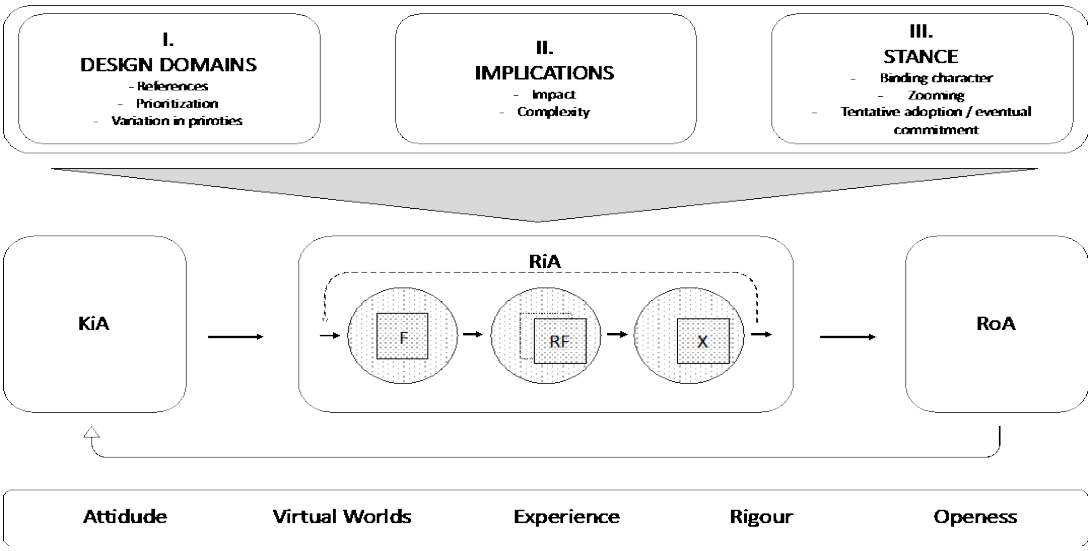

Figure 1. Framework of Reflecitve Practice

Stance towards the conversation with the situation is a kind of personal characteristic of the architect, HOW he is confronted with investigation. This is also a qualitative dimension. But more on the part of the architect and less easy to influence and implicit than the other two dimensions. New tools (VR, AR) make it easy to change perspective, both literally and figuratively. It can be possible to change the scale, but also to get away from the design.

5 Further Research

This purely conceptual framework shows possible starting points. However, the framework is only a preliminary orientation and a first attempt to better understand the creative problem-solving practices of practitioners.

As a next step, we propose to validate our framework. In order to do so, we will conduct design thinking-sessions (n=6). In three sessions the participants (n=8) are software-developers. The other sessions will be with participants (n=8) of the design-oriented practice (architects and industry designer (50%/50%). We suggest semi-structured interviews for further research to identify focal points within the framework at the beginning, in the middle and at the end of the session and validate the dimensions and process of framework.

With an iterative approach we will further develop our framework. So, after the first design thinking-sessions with designers and non-designers, we will revise the framework for next sessions.

The framework can help to understand which individuals` competencies and personal qualities do influence practical design thinking. That can help to gain insights on how to design systems that interact and collaborate between humans and robots (e.g. CSS) and how to adapt methodologies in order to make them more beneficial in the era of industry 5.0.

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Emergence in Design Science Research

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Abstract. Designing artifacts is a pivotal activity in Information Systems (IS) research. Beside the development process, the evaluation of artifacts is important as it allows the application of scientific methodologies to generate and accumulate knowledge. Commonly, the evaluation of an artifact is conducted in terms of the artifacts usefulness, utility or performance. Although those evaluation metrics are important, they do not allow conclusions on a more fundamental question, namely "What are fundamental components of an artifact?". Since Information Technology is becoming increasingly complex, identifying fundamental components becomes more important. To address this important topic, we draw from emergence theory to enhance artifact evaluation. We argue that emergence is a well-suited perspective that can be used to identify crucial components of an artifact. We provide a conceptual notion that can be applied to evaluate artifacts in the light of emergence and demonstrate conceptually how to apply this framework.

Keywords: Emergence, Design Science Research, Confirmatory Composite Analysis (CCA), IT Artifact Evaluation, Innovation

1 Introduction

Designing artificial objects is a pervasive human activity that significantly contributed to the evolution of humankind. For instance, the invention of a wheel to transport objects is considered a milestone in human history. In Information Systems (IS) research, designing objects receives the same attention as it allows to develop models, concepts, or artifacts to solve organizational and social problems (Hevner et al., 2004). Since designing artifacts is a crucial part of the discipline, design science research (DSR) emerged as a distinct research paradigm (Hevner et al., 2004; March & Smith, 1995; Simon, 1969; Walls et al., 1992) which in contrast to natural science, is concerned with the artificial (Simon, 1969).

A pivotal activity in DSR is the evaluation of design to demonstrate the utility or the usefulness of an artifact (Hevner et al., 2004; Venable et al., 2016). To ensure rigor, extant literature provides different approaches to guide DSR. Examples include the proposition of research guidelines for DSR (Hevner et al., 2004), research methodologies (Peffers et al., 2007), frameworks to evaluate artifacts (Venable et al., 2016) and the notions to develop and test design theories (Gregor & Jones, 2007; Niehaves & Ortbach, 2016).

Since Information Technology is becoming increasingly complex (Simon, 1962), the

evaluation of artifacts is becoming more challenging. Existing and emerging technology including mobile technologies and wearables (Barfield, 2016) and the dissemination of Individual IS (Klesel, 2019) further intensify the complexity of systems and challenges the evaluation of IT artifacts. Against this background it seems necessary to have an evaluation criterion at hand that allows the evaluation of an artifact in a most fundamental way, namely to identify and evaluate indispensable components of an artifact. This perspective is closely related to reductionism that seeks to reduce something to its very basic entities (Clymer, 1994). It is also in line with Popper who argues that the primarily objective of science is the proposition of generic statements (Popper, 2002).

So far, existing literature mainly focuses on specific evaluation matrices such as performance, utility or fit (Hevner et al., 2004) to evaluate an artifact. Consequently, fundamental questions like "*What components are required to address a specific objective?*" cannot be answered systematically so far. This lack has some considerable implications: First, without knowing fundamental design elements, a researcher is forced to include a great number of design components in the evaluation process. Alternatively, one can rely on heuristic approaches (Gregory & Muntermann, 2014) in dynamic environments. However, this approach might limit a systematic knowledge generation process (e.g., theory development). Second, with an exclusive evaluation of the overall performance of an IT artifact, design components which are not contributing to the performance of the artifact could be overseen. This leads to non-economic evaluation processes and the consideration of design components with little relevance (i.e. design gimmicks). Finally, without sufficient knowledge about fundamental elements, a refinement and an exploration of superior designs are challenging.

To address this issue, we posit that the principle of emergence provides an important enhancement to evaluate IT artifact. Emergence theory suggest that higher-level objects can be worth "*more than the sum of its parts*" (Ablowitz, 1939; Henseler, 2015). Consequently, we argue that emergence is well-suited to be used as an assessment criterion. As soon as an emergence phenomenon has been revealed, the designer is able to recognize super-summing effects. Hence, an IT artifact can be considered useful if the whole is worth more than the sum of its parts. In order to use emergence for design theorizing, we propose a conceptual model that primarily focuses on the synthesis of an IT artifact and inherits the idea of emergence.

2 Artifact Evaluation in DSR

At the core of DSR is the IT artifact (Hevner et al., 2004; Lee et al., 2015; Orlikowski & Iacono, 2001). Generally, an artifact is understood as something that can be transformed in a material or artificial existence, such as a model, an instantiation or a process (Goldkuhl, 2002; Gregor & Hevner, 2013). It is also assumed that most artifacts have a certain degree of abstraction (Gregor & Hevner, 2013). However, most of them can be easily transferred into a more concrete form for instance transferring programming code (e.g., an algorithm) into enterprise software (Gregor & Hevner, 2013). In line with previous literature, we further understand an artifact as a composition of related components and parts (Walls et al., 1992). This understanding is in line with General System Theory (GDT) (von Bertalanffy, 1968). According to GDT, an IT artifact can be generally understood as a composition of specific components which are, thus, "*part of*" an IT artifact (c.f. Figure 1). Moreover the artifact seeks to address specific goals. Hence, the concept also includes cause-effect relationships between the artifact and the intended goals.

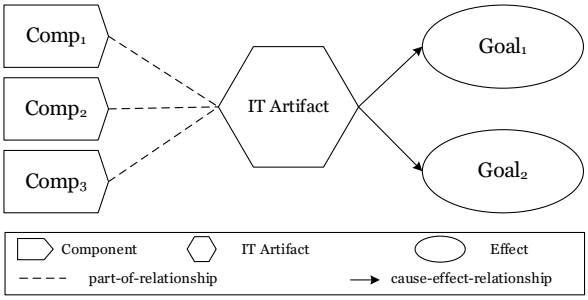

Figure 1. Conceptualization of an IT artifact

The evaluation of artifacts is crucial in DSR and should be rigorously demonstrated (Hevner et al., 2004; Venable et al., 2016). For this purpose, extant literature provided different approaches including methodologies (Peffers et al., 2007), guidelines (Hevner et al., 2004), frameworks (Venable et al., 2016), or theory-driven frameworks (Niehaves & Ortbach, 2016). In DSR, evaluation metrics are manifold including the evaluation of performance, reliability, usability or fit (Hevner et al., 2004). With regards to explanatory design theories, which focus on the environmental effects of an artifact (Baskerville & Pries-Heje, 2010; Niehaves & Ortbach, 2016), the evaluation can be implemented through the inclusion of a desirable or undesirable dependent variable. With regards to the generic conceptualization of an artifact, evaluation processes oftentimes focus on the goal or on specific components. For example, Peffers et al. 2007 reports that *"[a system] was found to be flexible and effective in this field of application*". Similarly, DSR investigating the explanatory aspects of an artifact are focusing on single effects and their effects. For example, Niehaves and Ortbach 2016 investigated the effects of media richness.

3 Emergence in DSR

3.1 Emergence Theory

Emergence arose from the Latin verb '*emergo'* which means to bring to light, to arise or to come forth and generally describe how an entity comes into existence (Vintiadis, 2016). The idea of emergence can be tracked back as far as Aristotle on the principle of entelechy, where he argues that the principle of growth is responsible for the qualities or form, that emerge within time (Clayton, 2006). Generally, a property can be described as emergent if "*it is a novel property of a system or an entity that arises when that system or entity has reached a certain level of complexity and that, even though it exists only insofar as the system or entity exists, it is distinct from the properties of the parts of the system from which it emerges.*" (Vintiadis, 2016). In other words, emergence can be described as "*more is different*" (Anderson, 1972) or "*less is different*" (Butterfield, 2011) respectively.

The concept of emergence can be found in various domains. For instance, an orchestra composted of various musicians and various instruments can evoke an emergent phenomenon. By overlaying different tones from different instruments, an orchestra is able to affect emotions which can only be addressed by means of a composition of various instruments playing at the same time. In contrast, listening to the notes and instruments separated from each other will not cause the same effects. This example demonstrate that an emergence effect may occur and that the whole is more than the sum of its parts. Note that the composer (i.e., the designer) can add or drop instruments in order to change the composition. Dropping to many instrument will lead to a point where some emotions cannot be affected anymore. Similarly, adding new instruments will not affect new or more intense emotions.

This phenomenon is also object of scientific debates. For instance in 2002, Malcom Gladwell published a book where he coined the term '*Tipping Point*'; an idea to describe "*mysterious changes*" (p. 7) who lead to completely new phenomena (Gladwell, 2002). Throughout his book, he proposes a variety of examples from daily life, including the emergence of new fashion trends or the outbreak of a disease (Gladwell, 2002). In academia this phenomenon has been discussed as *emergence* (Bar-Yam, 2004; Bedau & Humphreys, 2008; Clayton, 2006; El-Hani & Pihlström, 2002; Vintiadis, 2016). Examples

from research are manifold. A common cited example for emergence is the characteristic of water (i.e., liquidity and transparency), as it emerges from the properties of oxygen and hydrogen (Bedau & Humphreys, 2008). Another example from biology is the emergence of *life* itself as an interplay of chemical and biological properties.

Extant literature has named central assumptions in order to describe an emergent phenomena, namely *irreducibility*, *unpredictability*, *novelty*, and *holism* (Bedau & Humphreys, 2008). *Irreducibility* refers to the idea that an emergent phenomenon is autonomous with regard to the basic concept. In other words, it is not possible to reduce an emergent phenomenon. It is nevertheless assumed that there is a relation, which is commonly described as *supervenience* (i.e. the emergent phenomenon is distinct but depends on the more fundamental phenomena). *Unpredictability* assumes that with knowing the complete theory of basic phenomena it is not possible to predict emergence of an emergent phenomena. Another assumption is *novelty* which holds if a new conceptual or descriptive phenomenon is introduced. Finally, it is assumed that emergent phenomena appeal to holism. In other words, emergent phenomena only exist in a conglomerate of various more basic phenomena.

Previous IS literature acknowledged different perspectives of emergence (Hovorka & Germonprez, 2013) and its role for artefact mutability (Wessel et al., 2016). In specific, three different forms of emergence have been distinguished (Hovorka & Germonprez, 2013): (1) associative emergence, (2) combinatorial emergence and (3) emergence as process.

Associative emergence occurs if "*constituent parts are associated or aggregated such that the properties of the whole can be predicted by attending to the properties of the constituent parts*." (Wessel et al., 2016, p. 4) It is about deriving the whole out of its parts. The properties of the parts (components) are in focus. The whole is static and the properties of the parts are transformational.

Combinatorial emergence holds if "*constituent parts are combined or fused such that the properties of the whole are distinct from the properties of the parts, and the parts themselves are transformed*." (ibid., p. 5). Contrary to associative emergence the properties of the parts are static in that form of emergence at the beginning. The focus is about the combination of different parts (components) which lead to an effect that is finally transforming the parts themselves and also lead to a new whole. Therefore, the transformational effect of combining parts is focused.

Finally, **emergence as a process** "*focuses on patterns, timing, and intensity of interactions of constituent parts. Interactions may be planned or inadvertent*." (ibid., p. 6) It is about the process and not about the parts and the whole of their relation. So this complementary form of emergence is not supposed to help understanding the whole and the parts with regard to understand their interaction.

3.2 Application of Emergence in DSR

We depart from the notion that emergence can be used to investigate whether the composition of technological components cause emergent effects in a sense that the "*whole is more than the sum of its parts*" (Henseler, 2015). For an illustration, we use the framework shown earlier (c.f. Figure 1). Consequently, two scenarios can be distinguished:

(Genuine) Emergent phenomena: a desired or undesired effect can only be caused through the higher-level phenomenon (i.e. IT artifact). Hence, there is an exclusive relationship between the artifact and a goal (c.f. Figure 2). In reverse, lower-level components are not able to cause the effect. If this scenario occurs an emergent phenomenon occurs. At this point of time, a researcher can recognize the artifact as a new entity.

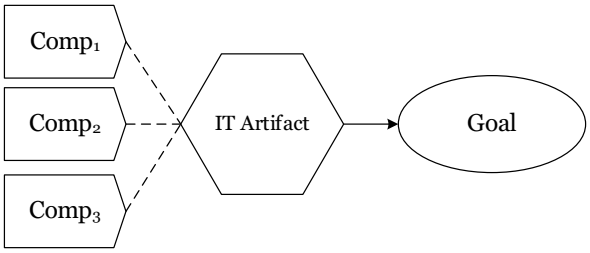

Figure 2. Emergent Phenomena

Resultant phenomena: a desired or undesired effect can be explained through one or more lower-level phenomena (here: components) and the higher-level phenomena. In other words, to achieve the goal, the composition of components is not required, as the effect (i.e., the goal) could also be caused by single component (c.f. Figure 3). Based on the principle of parsimony, it is recommendable to use only a component instead of a complex artifact. Hence, the composition of an artifact is not required necessarily.

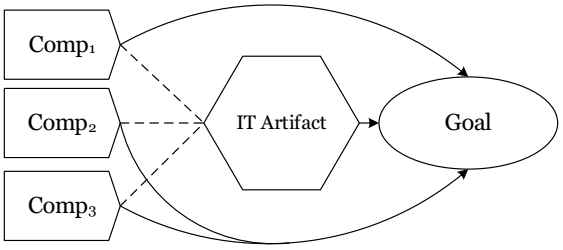

Figure 3. Resultant Phenomena

3.3 Application of Emergence

Emergence can be of use in various scenarios: First, it can be used to demonstrate that a specific configuration of components is able to cause a desired or undesired goal (c.f. Figure 2). This perspective is primarily of interest for new and disruptive innovations. Nevertheless, it might also be of interest for technologies that are known but without extensive theorizing. Second, it can be used to demonstrate that the extension of artifact components is meaningful as it influences a specific goal (c.f. Figure 4). This scenario ("*emergence through artifact extension*") commonly occurs when IT artifacts are redefined or extended including contemporary technologies. For example, if mobile technologies are extended with a GPS system, they address new goals (e.g., location dependent services).

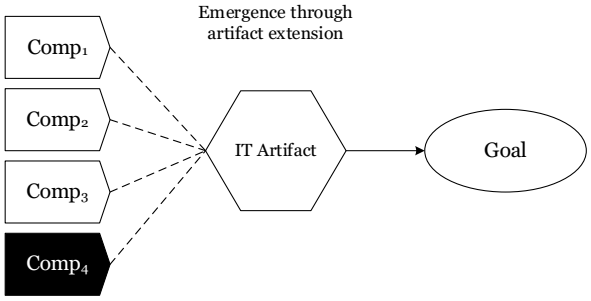

Figure 4. Emergence through artifact extension

Finally, emergence can also be used, to identify new effects. For example, if an IT artifact is applied in a new environment, or analyzed from a new perspective that allows the demonstrate that an artifact has an influence on a yet unknown goal or effect, emergence can also be used for justification (c.f. Figure 5). Again, this scenario is most likely with regards to technologies that are already studied.

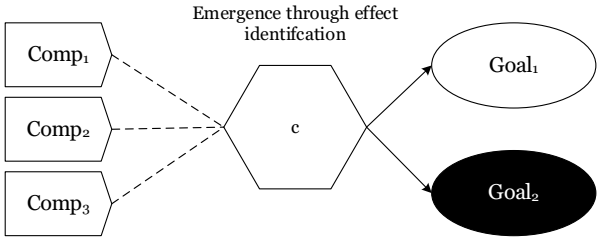

Figure 5. Emergence through effect identification

4 Discussion

Previous literature argued that emergence is related to artifact mutability in IS design theories (Gregor & Jones, 2007; Wessel et al., 2016). We agree that emergence is an important aspect of a design theory. However, it seems that emergence is not only relevant with regard to artifact mutability but can also be considered a general perspective for the evaluation of design theories. In fact, the proposed conceptualization is well-aligned with the anatomy of a design theory (Gregor & Jones, 2007). First, the *purpose and scope* is defined by the inclusion of goals. For instance, one may use this framework to build a system that enables social presence. Second, *constructs* are included in two ways: components and goals.

Components are manifold including text-, audio-, and video-elements. Goals are commonly captured as latent factors such as user satisfaction. Third, the *principle of form and function* can be provided in terms of a graphical representation of a new composite-theory (similar to the framework above). Forth, the *artifact mutability* can be included through the inclusion or exclusion of components. Fifth, *testable propositions* are included both from a component to an artifact as well as from an artifact to several goals. Finally, *justificatory knowledge* can be included to inform the inclusion or exclusion of components. In summary, the conceptual notation inherits the fundamental requirements of an IS design theory and refers to emergence as an evaluation criterion.

Due to the generic nature of emergence as an evaluation criterion, it is not limited to a specific methodology or a distinct research paradigm. Quite the opposite, it is perfectly suited to be part of existing research methodologies (Peffers et al., 2007) or can be used as an evaluation lens in existing DSR guidelines (Hevner et al., 2004). Emergence can also be included in the evaluation of design theories (Gregor & Jones, 2007). Since the notion used here, is well-aligned with the notion of a design theory, it can be easily applied within the development and evaluation of design theories. With regards to empirical methodologies, emergence can also be of use in both qualitative and quantitative approaches. The assessment of an emergence effect can, thus, be demonstrated by means of expert interviews or focus groups. Moreover, quantitative approaches including Structural Equation Modeling can be used by means of composite models and confirmatory composite analysis in specific (Henseler et al., 2014; Schuberth et al., 2018).

In order to reveal emergent effects, it seems that some form of experimental research is most promising. In line with existing literature that highlighted the usefulness of experimental research in design science (Kampling et al., 2016), emergence is also likely to be investigated within an experiment. A systematic manipulation of components and the continuous investigation of an effect, experiments seems to appropriate for this perspective.

From a theoretical perspective, our framework prepares the ground for more research that is concerned with the synthesis of an artifact as it emphasize the role of design components. We hope that focusing on components helps to enhance design research in IS as it relates directly to the artifact. Hence, this research also contributes to an ongoing discussion about the role of artifacts in IS research and the conceptual distance (Orlikowski & Iacono, 2001). The investigation of emergent effects caused by artifact design is, thus, closely intertwined with an artifact. Using a conceptual notion as used above (c.f. Figure 1) has also the potential to communicate DSR. Following Gregor and Jones (2007), it is crucial to find an effective communication in DSR. Both the conceptual notion and the use of emergence as an evaluation criterion that can be used to communicate DSR.

Extant literature in DSR argued that radical innovation has rarely been achieved in IS research so far (Gregor & Hevner, 2013). Although we agree that disruptive innovations including the world wide web are rare indeed, we also acknowledge that literature oftentimes miss an objective criterion to justify innovation. Emergence has the potential to contribute to (artifact) innovation by providing transparent criterion that helps researchers (and designers) to justify a new artifact. We proposed three different avenues to use emergence (i.e. emergence in general, emergence through effect identification, and emergence through artifact extension) that are all equally useful to justify a new class of artifacts. Note that detecting an emergent effect still needs a careful justification to argue for a (disruptive) innovation. It is more likely, that emergence enhance the objective criterion to justify what Gregor and Henver (2013) call "*improvement*" or "*exaptation*".

The emphasize on design components also contribute to knowledge development and theory integration. If a new artifact is recognized (i.e. by means of an emergent effect), other researchers can built upon this knowledge and further evaluate the composition in different scenarios. This practice is commonly known in handicraft professions and production industry where the fundamental components of a receipt (e.g., for the composition of a drink) have been identified and continuously refined. Having a conceptual notion in place that focuses on the component and emergence as an evaluation criterion, this practice can be adopted for IS research.

The application of this framework has several implications for practice: First, having evaluation results in place that provides evidence for the emergence of a desired or undesired effect, a designer (e.g., software architect) is able to include those fundamental components in order to address this issue. Based on that, practice can further enhance the components and add context-specific components.

Second, in line with the identification of fundamental components, a designer is also able to identify components that do not contribute to a specific effect. For example, brandings or customer gimmicks could enhance the appearance of an artifact, but do not contribute to a desired effect (e.g., satisfaction with the artifact). Nevertheless, it needs a careful justification whether to keep or getting rid of a specific component.

Finally, emergence can be used to justify a new class of systems (i.e., a new artifact). Therefore, it can be seen as guidance within design processes. Both academia and practice oftentimes struggle to justify that something new was developed (Gregor & Hevner, 2013). The concept can be used to demonstrate the uniqueness of a design configuration, which in turns help practitioners to demonstrate the quality of a new artifact.

5 Limitation and Outlook

Based on the scope of this article, there are several issues that opens the door for future research. First, the focus of this paper is on emergence in order to demonstrate that the composition of components leads to effects which could not be addressed by means of single components ("*the whole is more than the sum of its parts*"). We acknowledge that emergence theory has other components that are not included in this perspective. For instance, the aspect of unpredictability has not been included since unpredictability makes a design process nearly impossible. In other words, it is impossible to design an artifact for unpredictable objectives. However, with the raise of big data and heuristic theorizing (Gregory and Muntermann 2014), this aspect could be of further interest and requires further investigations.

Second, as this paper is conceptual in nature, future research is able to investigate the strength and weakness of various methodologies with regard to the implementation of this approach. As for now, different approaches could benefit from this perspective. Methods that are designed for hypothesis testing might benefit from the close relationship to IS design theories. Confirmatory composite analysis (Schuberth et al., 2018) which is well aligned with this persepctive is most promising. In this line, future research could investigate different methodologies and elaborate specific requirements to use emergence as a criterion.

Third, we put emphasize on combinatorial emergence. Therefore, the remaining two facets have not been investigated in detail. Both associative emergence and emergence as a process are important perspectives for IS research in general and DSR in specific. There are promising perspectives to investigate those remaining aspects with existing concepts and methodologies in DSR. As a starting point, emergence as a process could be integrated in DSR methodologies (Peffers et al., 2007) that

are designed for process-driven design endeavors.

Finally, we proposed emergence as a useful criterion in the evaluation process. We acknowledge that in various scenarios, the identification of something new is not top priority. In fact, designing Information Systems that requires a high degree of security, are less interested in the emergence of new effects but are exclusively focuses on security. This might also be true for systems that are designed for high performance or high level of batch processing. Thus, emergence might not be relevant for all technologies. Nevertheless, for a broad spectrum and end-user systems in particular emergent effects are of relevance and should be in line with existing metrics (e.g., usability). If a new effect emerge and another (important) effect diminish, a major potential of this approach is weakened. Consequently, future research should investigate how the interrelationship between existing effects and emergent effects are.

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Developing a Smart City Strategy by use of St. Gallen Management Model focused in Smart Mobility and Smart Environment

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Abstract. Cities are getting bigger and more crowded. This leads to an overuse of water-/ energy- resources and infrastructure, which are partly irreversible. In order to be a worth living place in the future, parts of a city have to change, e.g. housing, mobility, and supply of urban life, in harmony with nature and environment. For these changes a city, a so-called Smart City, needs a strategy. This paper will examine whether the St. Gallen Management Model (SGMM) can be a basis for the Smart City strategy process. For this purpose, the three sectors of the SGMM are analyzed in more detail and applied to the context of a Smart City, focusing on the power ranges Smart Mobility and Smart Environment. The analysis demonstrates that the transferability of the SGMM to the research application Smart City is well given, especially in the aspects stakeholders and environmental spheres of the sector environment and in the aspects frames of reference of the sector organization.

Keywords: Smart City, Strategies, SGMM, Smart Mobility, Smart Environment

1 Introduction

1.1 Motivation

A United Nations study shows that people have been moving to urban areas more and more since 1950. In 2050, 84.3% of the population in Germany will live in urban regions - for 2020, the value is 77.5% (United Nations, 2018). This change is followed by overloads in various parts of the city. For example, streets are crowded, which leads to high levels of congestion. The fresh water supply is insufficient, which is why fresh water has to be produced at great expense and wastewater has to be treated at great expense. The demand for energy is constantly increasing, which is why new and, above all, sustainable methods of generating electricity must be found. In addition, many city dwellers lead to high land use, increased consumption and pollution, of natural resources, increased air pollution and high noise emissions. These overloads are partly irreversible.

Overall, changes must take place in the areas of housing, mobility, and supply of urban life, which are in harmony with nature and environment. These changes will be expected to be shaped with the help of information and communication technologies (ICT) in order to consistently improve the quality of life of city dwellers. This redesigned type of city is called

a "Smart City" (Albino et al., 2015; Etezadzadeh, 2015; Gassmann et al., 2018).

1.2 Approach

For this context a strategy is needed to ensure that the transformation from a city to a smart city is successful. The strategy should fit the context of the application, here in particular mobility and environment.

This paper, therefore, deals with the question of what makes a successful strategy, which strategy makes sense for this context, and whether the St. Gallen Management Model is a suitable basis for the research area “Smart City”.

2 Theoretical Background

2.1 Strategic Management

Strategic management is defined as a "process which focuses on the formulation and implementation of strategies in [organizations]" (Welge et al., 2017). It is embedded between so-called normative management and operational management (Graf, 1999).

The normative management of an organization deals with both the main objectives of the organization and its norms, origins and principles in order to create value for the stakeholders. Thus, normative management creates the vision and mission of the organization and gives it an identity. In order to successfully realize the goals given by theoretical normative management, the organization has a strategic management in practice. It deploys resources based on the developments of the last years with the help of programs, structures, and systems using a scenario tree, so that new success potentials for the next years can be achieved. The main goal of operational management is to implement the input of normative and strategic management. Thus, this area includes all orders which will be handled with processes, cooperation, and performance in order to ensure that things are done in the visions’ way. (Bergmann & Bungert, 2013; Bleicher, 2011; Graf, 1999; Lombriser & Abplanalp, 2005)

There are various approaches to finally implement strategic management in practice. One approach is the interdisciplinary one. This is based on Charles Darwin's theory of evolution and follows the view that nothing can be controlled, but can be channeled and targeted, which is why this paper examine this further. An application model of the interdisciplinary (evolutionary) approach is the practice-oriented St. Gallen Management Model (SGMM). (Bea & Haas, 2016; Hungenberg, 2014)

2.1.1 St. Gallen Management Model

The SGMM offers the advantage that it can be changed at various positions, can be adapted to an organization without changing the core statement, and it reduces complexity enormously. For many years the condensed and clearly arranged third generation of the model was used. In 2017, this was replaced by the fourth generation, which is characterized by clearly separated sectors. In this paper, however, a combination of the third and fourth generation is presented, which integrates the advantages of both generations with respect to the topic of the paper. Consequently, all the advantages of the SGMM are achieved by the three main sectors: environment, organization, and management. All contributing factors are assigned to one of the sectors. These are shown in Figure 1 in blue, green, and orange, respectively. The external influences on the organization are included in the environment. The organization itself deals with the internal influences and the management sector handles the management of the organization. These relationships are presented in the following. (Rüegg-Stürm & Grand, 2017)

Sector: Environment This sector is subdivided into three aspects: environmental spheres, stakeholders, and resources. Environmental spheres provide the framework conditions for the organization and use according to this the resources. Exemplary environmental spheres

are society, nature, technology, or economy. Stakeholders either have a genuine claim on the organization, or have a representative function, or are affected in some way by the actions of the organization. Customers, dwellers, companies, or clubs are an example for this. The last aspect, the resources of an organization, are items or means that are brought to the organization by stakeholders on issues in order to share or exchange information about them. There are two types of resources: object-bound (like water, energy, or capital) and object-free resources (like know-how, trust, or patents). (Rüegg-Stürm & Grand, 2017, 2018)

Sector: Organization This sector is also subdivided into three aspects: types, frames of reference, and processes. Firstly, describing the six different types of organizations: companies, public companies, public organizations, non-governmental-organizations (NGO), non-profit-organizations (NPO), or pluralistic organizations. Secondly, the frames of references, which are based on the structure of strategic management and help to better sort future events and developments into the overall context and to legitimize them. For this purpose, they are divided into so-called horizons of meaning. The meaning's normative horizon gives the organization a sense of purpose and a responsible identity that creates a good social coexistence, makes cooperation possible, and thus increases economic success. In sum, it is the reason for the existence of the organization. The management of the meaning's strategic horizon acts on the basis of the meaning's normative horizon and carries out internal and external analyses. Afterwards, a strategy is chosen. Lastly, the meaning's operational horizon implements the chosen strategy to achieve long-term success. This encompasses three major processes: The management-process combines the design-, steering-, and development-process. The business-process takes over and regulates the practical implementation by means of customer- and performance-processes and their innovation. Finally, the support-process provides the necessary infrastructure and services. (Rüegg-Stürm, 2003; Rüegg-Stürm & Grand, 2017)

Sector: Management This sector is, according to Rüegg-Stürm and Grand, a reflective design practice that leads to stability through continuous and dynamic adaptation. This leads to the aspects of reflection and uncertainty. Reflection is important to ensure that goals and measures are realized, which results in continuous change and development. Other factors which influence reflective design practice are contingency and uncertainty, which hold opportunities and risks for the organization. Contingency is the possibility that organizational value creation can also take a different course - in line with the evolutionary theory approach. However, in combination with uncertainty (in terms of future development of the organization and their environment, other organizations, and the results of happenings) any change or renewal should be reflected, because uncertainty and contingency always require a detailed reflection. (Rüegg-Stürm, 2003; Rüegg-Stürm & Grand, 2017)

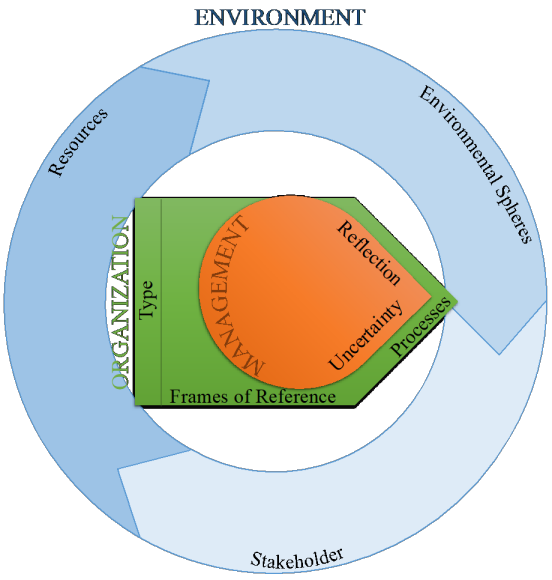


Figure 1: Structure of the SGMM used in this paper (own figure based on (Rüegg-Stürm, 2003; Rüegg-Stürm & Grand, 2017))

2.2 Research Application "Smart City"

2.2.1 Definition of a "Smart City"

Currently, there is no set definition of a "Smart City". In Europe, Doctor Giffinger from the

Technical University of Vienna (2007), or Doctor Caragliu from the University of Amsterdam (2009), or Doctor Gassmann from the University of St. Gallen (2018), for example, have formed possible definitions with different aspects. Based on these definitions and the other published definitions (Schäfer, 2019), this paper presents a definition, where all previously mentioned aspects have been covered and even expanded.

A "Smart City" is a city that uses natural resources in an environmentally friendly and efficient manner, strengthens economic growth sustainably to ensure long-term competitiveness, and uses ICT effectively in the areas of mobility, energy, building management and services, based on digital control. The security of data should always be guaranteed and both residents and stakeholders should be involved in the transformation process to create greater transparency and acceptance. This bundle of measures and intelligent solutions should improve the life's quality of the city's residents and visitors and promote satisfaction.

2.2.2 Power Ranges of a "Smart City"

Derived from the definition and the research results of Doctor Giffinger, there are six power ranges: Smart Economy, Smart People, Smart Living, Smart Governance, Smart Mobility, and Smart Environment. In this form, these were recognized by the European Union in 2014. It is important that the power ranges influence each other and are linked to each other at all times. For this reason, as many power ranges as possible should be integrated in a Smart City project in order to avoid negative synergy effects. Below, the power range, Smart Mobility and Smart Environment, are presented in more detail. (Giffinger, 2007; Manville et al., 2014)

An intelligent approach to the environment (Smart Environment) is an essential component of the Smart City. The ecological footprint of the city should be minimized as much as possible. This appertains to creating attractive and natural conditions within the city, for instance by the creation of generous green spaces, sustainable buildings, and sustainable urban planning. Also, it includes all-encompassing energy efficiency, a focus on renewable energies, environmental protection, noise reduction, air improvement, less pollution, and resource management. An intelligent mobility concept (Smart Mobility) is for the dwellers itself and its visitors. The external conditions ought to be right, by which local and international accessibility is meant. The internal conditions, by which the systems within the city are described, should be innovative, safe, sustainable, and functional in real time. In this case, a good connection trough integrated ICT in the transport systems of the city is a prerequisite. In addition, motorized individual traffic is to be minimized in order to reduce fine dust, emissions, and noise pollution in the city centers. This can be achieved with the help of car and bike sharing programs, autonomous buses, increased use of local public transport, or other mobility concepts. (Albino et al., 2015; Gassmann et al., 2018; Giffinger, 2007; Magistrat der Stadt Wien, n.d.; Manville et al., 2014; Morvaj et al., 2011)

2.2.3 Goals of a "Smart City"

The goals of a Smart City can be derived from the definition on the one hand and be concluded from it on the other hand. These goals are climate neutrality and resource efficiency, diversity and openness, open-mindedness and innovation, competitiveness and prosperity, participation and inclusion, responsiveness and sensitivity, security and enough space, and that the city is liveable and loveable. These goals should therefore be on the normative level when designing a Smart City.

2.3 Research question

Based on the theoretical background, the question now arises whether the SGMM can be applied to the Smart City research application, because it was previously only used i.a. in companies, medicine, economics, or environmental management (Doleski, 2015; Rimbach, 2013; Schwegler, 2003; Winter & Rohner, 2010). Hence, it has to be clarified how

the environment of a Smart City with the focus on Smart Mobility and Smart Environment looks like in relation to environmental spheres, stakeholders, and resources; how the structure of the organization looks like in relation to the type, frames of reference, and processes; and how the management looks like.

3 Methods

Firstly, the developed SGMM will be applied to the Smart City research application in two steps. In this work, the three areas of the SGMM are considered individually, one after another: starting with the environment sector (blue), then the organization area (green) and finally the management area (orange). In the end, the complete strategy is constructed by the addition of all three areas with their respective aspects, (right side in Figure 2).

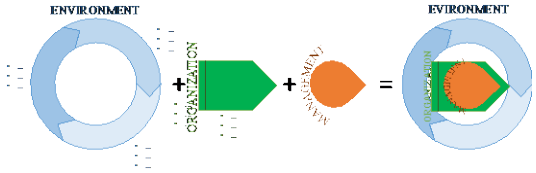


Figure 2: Strategy Development using the SGMM with the Smart City Influence

In the first step, the aspects of a sector, which were explained in chapter 2.1.1, are assigned to elements that are necessary for a Smart City. The sectors environment and organization are divided into three aspects and the sector management into two. In the second step, the subordinate elements of an aspect are linked to points that are particularly important in the area of mobility and environment. These points are grouped together as required to maintain clarity. The overall result of the procedure is that all points that are important in a Smart City project in the area of environment and mobility can be seen at a glance.

3.1 Stakeholder Analysis

In the sector of the environment, the stakeholder aspect is examined in more detail by means of a stakeholder analysis. The first step is the analysis of the expectations of the individual stakeholders regarding the Smart City (in its completed state), and the second step is the analysis of the expectations regarding the Smart City project (the implementation). In the third step, on the one hand the approval and on the other hand the influence and power of the individual stakeholders are weighted.

3.2 Frames of Reference Analysis

In the organization's sector, the aspect of the frames of references was examined in more detail by analyzing the horizons of meanings.

4 Major Findings

The results from the application of SGMM to the research application Smart City are shown in mind maps. In general, each sector is divided into the aspects. The aspects are then again divided into elements. At this point, the focus is placed on the sectors of environment and organization, because the deeper an organization is penetrated, the more individualized the management becomes.

4.1 Sector: Environment

The aspects of the sector environment are environmental spheres, stakeholders, and resources. Based on these, the elements of the aspect resources are for example object-bound and object-free. This is shown in Figure 3.

The result of the analysis shows that for a successful Smart City in the areas of mobility and environment, the following stakeholders must be part of the decision-making committee: dwellers, local (transport-, energy-, and water supply-) companies, politicians, investors, and state and federal legislation. This committee should be set up by the municipally of a city before the Smart City project starts.

4.2 Sector: Organization

The aspects of the sector environment are type, frames of reference, and processes. To illustrate, for example, the elements of the aspect "frames of reference" are normative, strategic, and operational. This is shown in Figure 4.

In the following, the aspect of frames of reference is discussed in more detail. On a normative level, the values and goals of a Smart City (see chapter 2.2.3) must be defined so that the existence of the organization and its relationship to the environment does not leave any questions unanswered. The strategic level serves to implement the normative level. Existence-promoting pre-requisites are to be created, which are acting in a long-term and future-oriented manner with regard to the environment. Considering this, a SWOT analysis of the city is created as the first measure. Consecutively, the normative goals are transformed into concrete goals, involving the stakeholders from the environment – see results of the stakeholder analysis in chapter 4.1. Next, working groups and vision are created so that infrastructure and resources can be planned. Finally, at the operational level, the normative level objectives are implemented. Since the implementation of the projects is largely project-specific, no concrete recommendations can be made at this point.

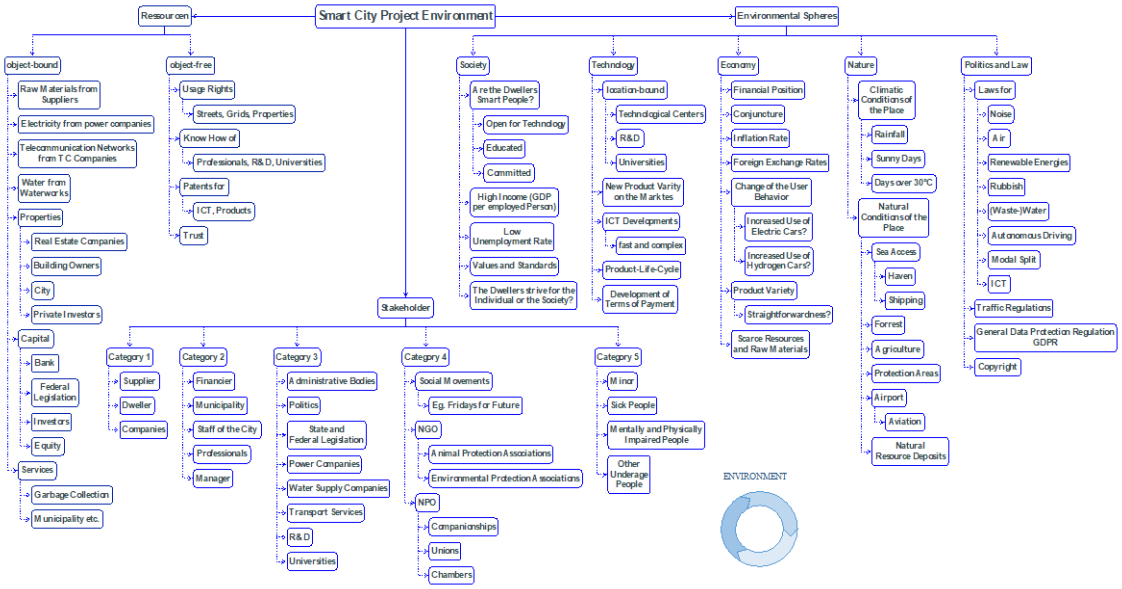
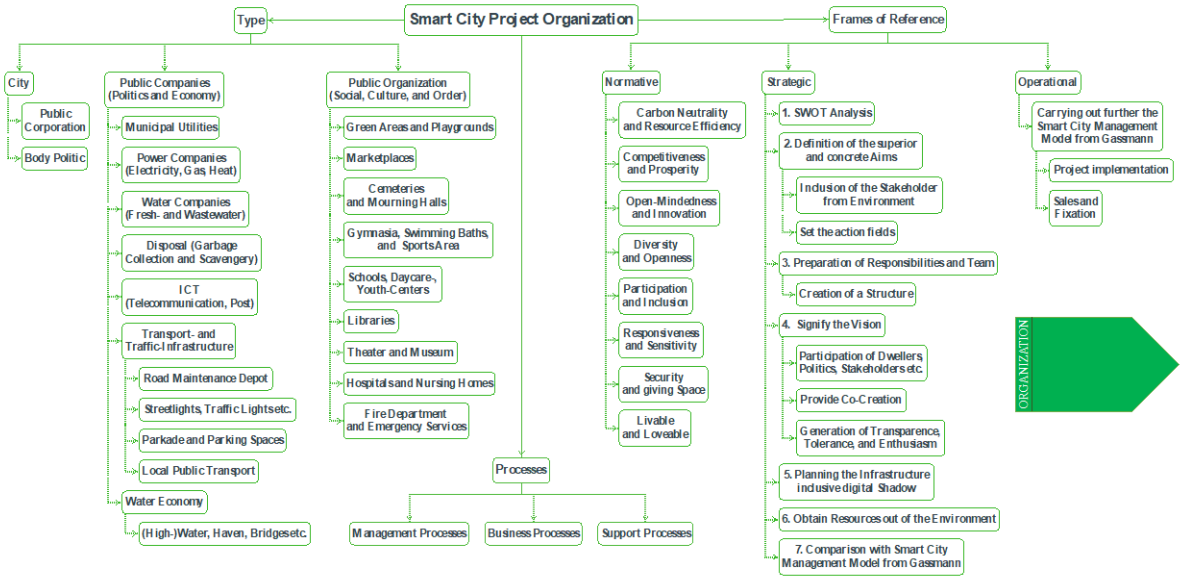


Figure 4. Analysis Results for the Smart City Strategy in the Sector Organization

Figure 3. Analysis Results for the Smart City Strategy in the Sector Environment



5 Discussion

From the main findings it can be concluded that on the one hand a precise analysis of the environment and its aspects is crucial for the success of the project. The stakeholders are important for the development process of a Smart City, because they have a huge implementation power to act for their Smart City, which is based on high willingness. For a thriving project, at least one stakeholder of each category should be involved in the project in order to avoid an imbalance and in consequence to avoid a coupling of interests of some stakeholders. Therefore, the decision-making committee should consist of representatives from the above-mentioned stakeholders. On the other hand, the organization should know exactly its strengths and weaknesses in order to be able to act optimally, as well as their specific project goals. As a result, the decision-making body, under qualified management and motivated helpers, can successfully carry out the project within the budget and time frame. In practice, these theoretical findings help enormously in the areas of mobility and environment when starting an urban transformation to a Smart City. The municipality of a city knows which stakeholders need to be involved in the project from the very first beginning in order to be successful. In addition, the findings provide valuable information on the entire range and depth of a Smart City project.

To the best of my knowledge and belief, an application of the SGMM (in third, fourth, or a combination) or other strategy models to the research area Smart City has not yet been analyzed. Furthermore, in this paper the application of SGMM was only studied on two areas, namely Smart Mobility and Smart Environment. Therefore, the SGMM should be adapted and applied to all six power ranges of a Smart City to elucidate interactions and multiple functions of stakeholders. This will highly probable result in an adaptation of the model that has been set up. For example, some stakeholders will have different attitudes toward and demands on the Smart City depending on their role and position within the different power ranges. Nonetheless, in this study the SGMM was successfully adapted and applied to the research application Smart City for the development of strategies for Smart City projects.

6 Conclusion and Outlook

The here demonstrated analysis shows that the SGMM can be applied to the research application Smart City in the areas of Smart Mobility and Smart Environment. However, it is essential to ensure that a thorough classification of all relevant elements to the sectors is made, as this is the basis for the Smart City strategy. Finally, all power ranges should be considered and the strategy should be tested in reality in order to validate the feasibility of strategies proposed by SGMM Smart City strategies as well as to integrate not captured influences arising from reality into the SGMM Smart City projects.

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