Leveraging Information Systems to Foster Sustainable and Healthy Behavior Change

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Leveraging Information Systems to Foster Sustainable and Healthy Behavior Change

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Dedicated to Erhard Graichen.

"We know what is happening to our planet.

We know what we need to do. And we even know how to do it.

But sadly, the ambition of our action is nowhere near where it needs to be."

- Guterres (2018)

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Contents

Abstract

In recent decades, technology has emerged as a beacon of hope to aid humanity in addressing two pressing issues of our time: human health and climate change. However, despite advances in medicine and climate technology, rates of infectious diseases (Jones et al., 2008) and carbon dioxide emissions (Olivier & Peters, 2020) continue to rise. Alongside technological and systemic regulations, it is also the behavior of each individual that contributes to curtailing infectious diseases and carbon dioxide emissions. Yet, individuals often struggle to align their good intentions with their actual behavior. This gap underscores the complexity of breaking ingrained habits and adopting new behaviors, demanding more than mere intention. The question of how to achieve behavior change in the context of health and climate change is not easily answered; it requires extensive interdisciplinary research.

Information Systems research can support and advance the study of behavior change through digital interventions. Digital interventions, due to their availability and scalability, stand as promising tools for facilitating behavior change and research. The inclusion of measurement instruments within technological devices furthermore allows for the collection of real-world behavioral data. Consequently, Information Systems research can not only contribute but also enhance the empirical validation and expansion of behavioral theories. Despite the potential that Information Systems hold in the realm of behavioral research, it remains a domain far from being fully explored. The main objectives of this dissertation are to provide insights into the effectiveness of digital interventions in fostering healthy and environmentally sustainable behavior within the real-world context,

alongside the empirical validation of behavioral and motivation theories. To accomplish this, the dissertation adopts an interdisciplinary approach encompassing two experimental field studies and one survey field study. The field studies are centered on behavior change in the realms of health and sustainability behavior among children and employees.

The first two chapters revolve around the outcomes of two large-scale field experiments, investigating hand washing behavior of children in day care centers. Within Chapter 1, a digital intervention is designed and the applicability and effectiveness of the intervention are affirmed across day care centers in Finland and Germany. The data indicate that soaping time of children, a proxy for hand washing quality, can be improved by 62% while the digital behavior intervention is in place. In Chapter 2, the intervention subsequently serves as a tool to empirically validate and expand behavioral theory, specifically the Motivation Crowding Theory. The results provide empirical evidence for the efficacy of digital rewards in children. This underscores the value of digital rewards while disproving potential negative effects as suggested by the Motivation Crowding Theory. The findings of Chapters 1 and 2 underscore the effectiveness of digital behavior change interventions leveraging digital rewards both in research and in practice. The research undertaken in this context can serve as a blueprint for Information Systems researchers venturing into behavioral research, particularly with children. Moreover, it offers practitioners guidance for the design of effective and scalable systems tailored to children.

Chapter 3 presents the results of a field study that examines the motivations of train drivers to use Green Information Systems in the workplace and thus to contribute to energy savings in the transportation sector. The results of the interviews and surveys conducted for this purpose confirm the applicability of the Protection Motivation Theory in the context of Information Systems. The collected data show that employees' motivation to engage in climate-protective behavior depends on their perception of their own response efficacy and the severity of climate change. The identified motivations provide important starting points for the development of digital behavior interventions aimed at promoting environmentally friendly behavior among employees.

Overall, this thesis illustrates that Information Systems can support human behavior change, and serve as a tool to measure and examine behavior change and underlying behavioral theories. The conducted field studies underscore the effectiveness of digital interventions in real-world settings. With the chosen interdisciplinary approach and a combination of different methods, existing behavioral theories are utilized in the field of Information Systems, empirically validated, and expanded. The research emphasizes that Information Systems have the potential to assist individuals in changing their health and sustainability behavior, addressing two pressing issues of our time.

Abbreviations

CO_2	Carbon Dioxide
DID	Difference-in-Differences
IS	Information Systems
MCT	Motivation Crowding Theory
PMT	Protection Motivation Theory
SEM	Structural Equation Modeling

Introductory Paper

1 Introduction

This chapter presents an overview of the general motivation and objectives, along with the overall structure of this cumulative dissertation.

1.1 Motivation

Each and every one of us has a responsibility to ensure the well-being of future generations alongside our own personal growth (United Nations, 2015). The United Nations (2021) has defined 17 goals to achieve sustainable development, with two goals, "good health and wellbeing" and "climate action," being highly prominent in today's public debates. These two goals, and the potential of Information Systems (IS) in this context, form the focus of this dissertation.

In terms of health, the last decades have brought considerable medical advancements, improving the treatment of existing diseases. However, there is a need to shift more attention towards disease prevention as most major health problems in industrialized countries can be attributed to unhealthy behavior (Khaw et al., 2008; McGinnis, Williams-Russo, & Knickman, 2002). Poor diet leading to high obesity rates (World Health Organization, 2021) and low compliance with hand hygiene practices resulting in the spread of infectious diseases (Bloomfield, Aiello, Cookson, O'Boyle, & Larson, 2007; Randle, Clarke, & Storr, 2006) are only two of numerous examples of behavior induced health problems. Despite individuals' knowledge of healthy behavior and how it could lead to a healthier live, there is often a disconnect between intention and behavior. This phenomenon, known as the Intention-Behavior Gap (Sheeran & Webb, 2016), not only affects adults but also poses challenges for children in learning and adopting healthy behaviors (Isa, Ueda, Nakamura, Misu, & Ono, 2019). Given that children are particularly vulnerable and susceptible to the impact of diseases (Shivayogi, 2013), it becomes crucial to address this issue. Furthermore, establishing healthy habits during childhood often translates into

healthier adulthood (Forrest & Riley, 2004).

In the realm of climate change, we observe a similar phenomenon. Despite the advancement of technology and increased public awareness, global greenhouse gas emissions are on the rise (Olivier & Peters, 2020). The integration of renewable energy sources continues to pose challenges (Sinsel, Riemke, & Hoffmann, 2020), and the adoption of green technologies by businesses requires substantial investments. Furthermore, even if the production of energy and goods becomes greener, it is essential for individuals to rethink their attitudes and change their behavior to act and consume sustainably. However, altering everyday behaviors is difficult, and again, there exists a gap between individuals' intentions for sustainability and their actual behavior. This discrepancy is particularly evident in the transportation sector, which is a substantial contributor to Carbon Dioxide (CO_2) emissions (Federal Statistical Office of Germany, 2020). While technological advancements and policies play a vital role in reducing emissions in the transportation sector, they are most effective when coupled with behavior changes by individuals. Private households possess the potential to contribute to emission reduction by altering their transportation choices in their daily lives. Similarly, employees within the transportation sector can influence emissions through their driving behavior. However, modifying habits in the workplace as an employee is just as challenging as changing behaviors in one's private life.

Fortunately, IS can support behavior change to foster healthy and sustainable behavior. By examining how IS can impact health and sustainability behavior change, this dissertation aims to provide theoretical knowledge, practicable recommendations, and actionable implications for researchers, organizations, and individuals to effectively address these pressing challenges and create a positive impact for future generations.

1.2 Objective and Contribution

The aim of this thesis is to examine how IS can foster healthy and sustainable behavior change of individuals, in one case young children, in the other case skilled workers. The

presented research studies investigate how IS can help increase the motivation of children and employees to employ certain health or sustainability behaviors, making use of behavioral theories from different fields. By integrating research from various disciplines such as IS, behavioral economics, social science, education science, and psychology, this thesis recognizes that addressing the complex challenges of health and sustainability requires an interplay of different disciplines.

Although health promotion and sustainability may initially appear as distinct topics, a closer examination reveals similarities, with several theories being suitable to investigate behavior in both domains. Independently from the domain, empirical validation plays a crucial role in understanding behavior, as theories and laboratory work alone cannot provide a comprehensive view. Hence, this thesis adopts mixed method approaches, incorporating field experiments to measure the tangible effects of IS in real-world settings. By combining theoretical frameworks with empirical evidence, a more robust understanding of behavior in the context of health promotion and sustainability can be achieved. The empirical findings contribute to bridging the gap between theory and practice, providing evidence-based guidance for the implementation and utilization of IS solutions.

Concretely, this dissertation delves into the applicability of two behavioral theories, namely, Motivation Crowding Theory (MCT) and Protection Motivation Theory (PMT), within the IS context. It offers empirical substantiation that digital rewards do not yield adverse consequences on children's health prevention behavior, a result contrary to MCT predictions. Moreover, the dissertation underscores that the PMT, originally rooted in the health domain, can effectively probe the motivational dynamics of employees within the Green IS context.

The objective of this thesis is to make meaningful contributions to scientific theory while offering implications for practitioners in implementing practicable IS solutions in real-world contexts. Ultimately, this research endeavors to contribute to the broader goal of promoting health prevention behaviors and mitigating the impacts of climate change through effective and scalable IS interventions.

1.3 Approach

This dissertation consists of the Introductory Paper as well as three chapters, summarizing seven research papers, which provide more detailed insights into the potential of IS to foster behavior change of children and employees. Figure 1 provides an overview of the chapter structure and the comprised papers, including their topic and methodology. The seven research papers collectively cover three field studies: two experimental field studies and one survey field study. The approach combines empirical investigations within the scope of the field studies, aiming at producing novel insights on children's health and employees sustainability behavior, with literature reviews, outlining the relevance of the topic and establishing conceptual knowledge. The unique potential of field studies, further explored in greater depth within the Theoretical Background (Section 2) and Methodology (Section 3), allows for insights that would not be attainable through literature reviews or laboratory studies.

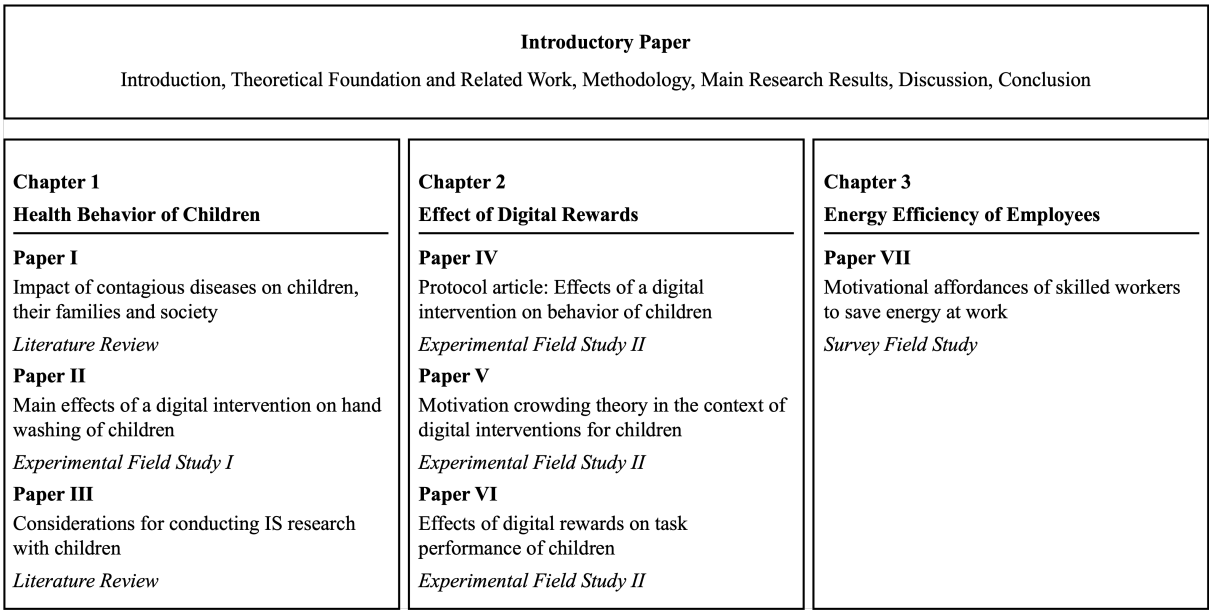

Figure 1: Overview of the structure of the dissertation, including the Introductory Paper and three chapters with seven research papers.

The first part of the dissertation, Chapter 1, focuses on the design and evaluation of a digital health intervention for young children. The intervention aims to help children learn

everyday health prevention behavior, specifically hand washing. The research in Chapter 1 (and Chapter 2) is part of the interdisciplinary research project *Candy*, conducted by researchers from the fields of IS and Nursing Science, at universities in Germany and Finland, supported with practical knowledge and hardware by the companies *Oras* and *Amphiro*. The first research article (Paper I) provides an overview of the consequences of contagious diseases among children in day care centers, highlighting the relevance of the chosen use case hand washing. The second research article (Paper II) presents the first field experiment, evaluating a digital intervention to improve hand hygiene among young children. The study assesses the effect of the digital intervention on hand washing performance by collecting sensor, interview, and survey data over a period of eight-and-a-half-weeks in day care centers in Finland and Germany. The third research article (Paper III) presents important considerations for IS research with children, condensing findings from the field experiment and relevant literature.

The second part of the thesis, Chapter 2, builds upon the digital health intervention introduced in Chapter 1 and delves deeper into the underlying behavioral mechanisms and theories that drive behavior change in children. Specifically, this chapter investigates the influence of digital rewards on children's motivation in a second field experiment. The goal is to examine the validity of MCT in the context of digital rewards and young children. The field experiment utilizes an enhanced version of the digital intervention from the first field experiment to specifically examine the influence of rewards on children's motivation while the rewards are present and when they are withdrawn. Paper IV serves as a protocol article, providing a detailed description of the experimental setup for the second field experiment in the dissertation. Paper V further explores the objectives of the field experiment within the IS context and presents related work regarding MCT in IS literature and MCT in the context of children. The results of the field experiment, including implications for MCT and digital rewards, are presented in Paper VI.

The third part of the thesis, Chapter 3, shifts the focus from young children and health behavior to skilled workers and sustainability behavior. The chapter includes survey re-

search conducted with a large European mobility provider, offering the opportunity to collect real-world data on the interplay of IS and the motivation of employees to save energy on the job. In particular, the motivation of train drivers to drive energy-efficiently is examined, as they can have a substantial impact on energy savings in the transportation sector. The seventh research article (Paper VII) introduces PMT, showcases its relevance and efficacy to investigate the motivation and usage of Green IS among skilled workers, and summarizes findings from the survey study.

Each paper included in this thesis adheres to the standard structure of a research endeavor, encompassing the dimensions of motivation, theoretical background, research model (if applicable), approach / methodology / research design, results, discussion, implications, and conclusion (Recker, 2013). However, within the overall structure of the dissertation, the papers assume varying levels of importance across the different structural dimensions, as depicted in Figure 2.

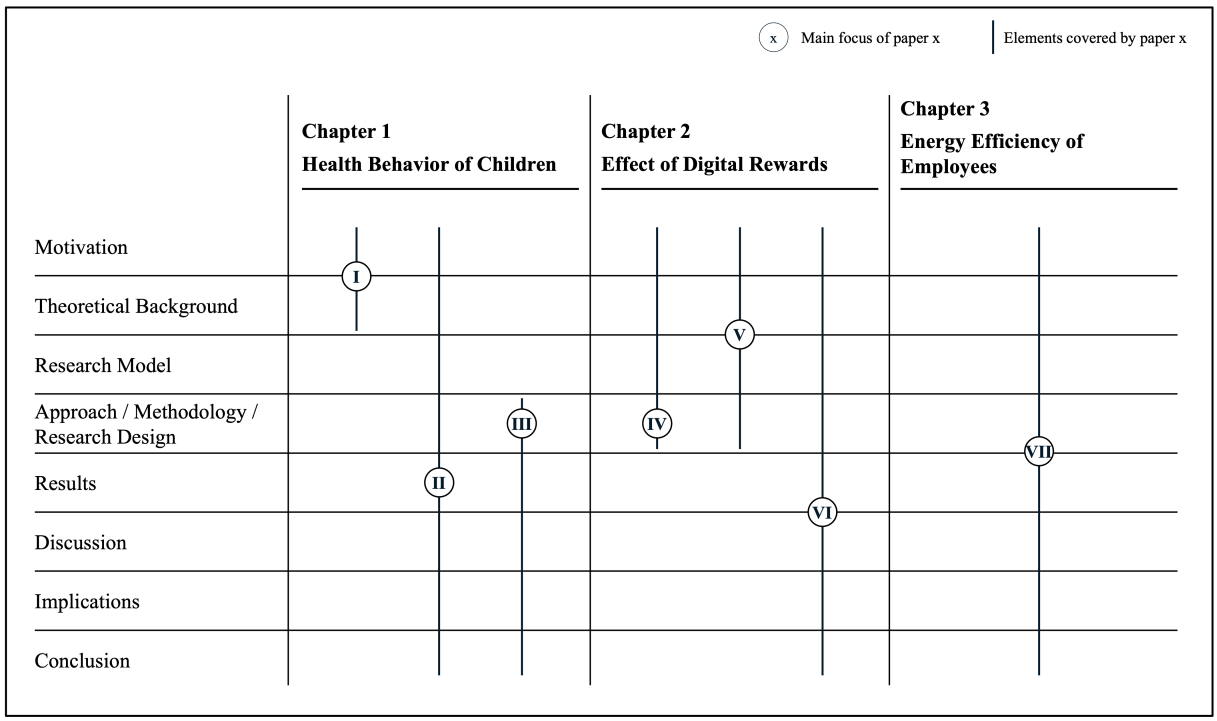

Figure 2: Contribution of the research papers to the structural components of each chapter in the dissertation.

Chapter 1 is primarily motivated by Paper I, which explores the impact of poor hand hygiene among children on themselves, their families, and society. This serves as the rationale for investigating the hand washing use case in Chapter 1 and Chapter 2. While Paper II provides the motivation, methodology, and research design of the first field experiment, its main focus lies on the analysis and discussion of the obtained results. Paper III discusses the unique aspects of conducting IS research with children, emphasizing the research approach and drawing implications and conclusions based on the experience gained from the first field experiment.

In Chapter 2, Paper IV and V primarily cover the initial stages of the research structure, while Paper VI encompasses primarily the final stages. Paper IV, serving as the protocol article for the second field experiment, emphasizes the motivation, background, and design of the field experiment, as expected from its nature as a protocol article. Paper V focuses on the motivation, theoretical background, research model and research design considerations of the field experiment from an IS perspective. Paper VI builds upon the detailed accounts of the field experiment provided in Papers IV and V, focusing on the analysis, discussion, and derivation of implications and conclusions from the field experiment.

Chapter 3 solely relies on Paper VII, which covers the entire research structure. It motivates the survey field study, provides theoretical foundations, describes the research design, evaluates and discusses the results, and derives implications.

1.4 Thesis Outline

The structure of this cumulative dissertation is as follows: The remainder of the Introductory Paper presents an overview of related work relevant to this thesis, addresses research gaps (Section 2), and provides an overview of the methodology used in the various research articles (Section 3). The Introductory Paper then presents a synopsis of the findings from the included research articles (Section 4), discusses overall contributions and limitations (Section 5), and closes with a conclusion (Section 6).

Chapter 1, Chapter 2, and Chapter 3 consist of seven separate research articles that have either been published or are currently under review at peer-reviewed publication outlets. Please refer to the Publications (A.1) and the Disclaimer (A.2) in the Appendix of the dissertation for more information.

2 Theoretical Foundation and Related Work

The main focus of this thesis is to explore how IS can effectively motivate behavior change in young children and skilled workers. This section provides an overview of the theoretical foundation and related work regarding behavior change and motivation, and its connection to IS research. While this section contextualizes the various research articles, in-depth information about the relevant literature for the articles of Chapter 1 to Chapter 3 is contained directly within the papers. This section begins with a brief overview of behavior change across disciplines, followed by an introduction to behavior change in the field of IS. Subsequently, the specific concept of motivation and its role in behavior change and IS research is examined in more detail, an aspect that holds significance throughout the various chapters of this dissertation and unites them. The section closes by addressing the research gaps that emerged during the exploration of related work.

2.1 Behavior Change Research

behavior change research holds a prominent place in various disciplines, ranging from psychology to economics and beyond. In the realm of psychology, pioneers like Watson (1913) and Skinner (1953) laid the foundation for behavior change theories, emphasizing the influence of external stimuli on observable behaviors (Heimlich & Ardoin, 2008). Economics, traditionally built on the assumption of rational decision-making, eventually incorporated insights from psychology, giving rise to behavioral economics that recognizes the impact of cognitive biases (e.g., anchoring and framing) on choices (Camerer & Loewenstein, 2004; Brown, Cameron, Wilkinson, & Taylor, 2020). The interdisciplinary nature of behavior change becomes evident through its application across diverse domains, ranging from behavior change in the context of health, e.g. smoking cessation (Sharma, Khubchandani, & Nahar, 2017), to personal finances, e.g. retirement savings (Benartzi & Thaler, 2013). Similarly, educational practices draw on concepts from behaviorism, such

as stimulus-response mechanisms (Heimlich & Ardoin, 2008). The widespread interest in behavior change is reflected not only in the substantial research activity in the field (Wendel, 2013) but also in popular books accessible to the general public, as exemplified by Ariely (2010) and Kahneman (2013), the latter being a Nobel Prize recipient for his contributions to behavior change research. Nowadays, behavior change and its research becomes especially pertinent as it can directly affect personal well-being and ecological sustainability (Hermsen, Frost, Renes, & Kerkhof, 2016).

Two prerequisites for behavior change are knowledge, which entails understanding what the target behavior entails, and skills, which refer to the ability to perform the new behavior (Knittle et al., 2020). However, even when these two prerequisites are met – when individuals know what behavior they intend to exhibit and possess the skills to do so – they often still struggle to make the desired behavioral shift (Duckworth & Gross, 2020), e.g., as frequently evidenced in the aforementioned case of smoking cessation. The focus of research lies in understanding how behavior change can succeed when information and skills are not the barriers. Behavior change research thus endeavors to uncover the causality behind why individuals adopt or abstain from specific behaviors (Heimlich & Ardoin, 2008). Particularly, behavior change related to daily routines and habits appears intricate, demanding a high degree of self-efficacy and motivation (Winfield & Whaley, 2002; Hermsen et al., 2016). Numerous recognized internal and external conditions influence individuals to exhibit particular behaviors (Heimlich & Ardoin, 2008). A plethora of theories, such as the Theory of Planned Behavior (Ajzen & Schmidt, 2020), Social Cognitive Theory (Bandura, 1989), and the Transtheoretical Model of Behavior Change (Prochaska & DiClemente, 1983), delve into the conditions influencing behavior change. These theories can be integrated into behavior change interventions, defined as targeted and purposeful alterations in the environment to influence behavior (Geller et al., 1990). Behavior change interventions have evolved to encompass an array of techniques and strategies, with reviews identifying up to 100 distinct behavior change techniques (Michie et al., 2013; Kok et al., 2016; Knittle et al., 2020). Alongside the often compartmental-

ized examination across different disciplines, this multitude of behavior change techniques contributes to the challenge of drawing definitive conclusions for behavior change research and practice. Consequently, it is difficult to predict the extent to which behavior change theories can be extrapolated to IS and thus, how digital interventions can impact behavior change.

2.2 Information Systems for Behavior Change

IS research and practice have historically been centered on two key aspects: the economic impact of IS, often rooted in neoclassical economic theories, and the technical aspects of systems. This focus has often led to the oversight of cognitive effects that IS can have on individuals (Goes, 2013). However, given that IS involve the processing of data and information that influence individuals' decisions and behaviors, it is imperative that behavioral economics assumes a prominent position on the IS research agenda (Goes, 2013; Yoo, 2010).

The progress in technology offers, next to its potential to facilitate behavior change through digital interventions in practice, potential for behavioral research in the IS discipline (Dallery, Kurti, & Erb, 2015). Behavioral research can play a decisive role in addressing issues well known to the IS discipline such as trust, privacy, security, and user participation (Goes, 2013). Furthermore IS can actively participate in shaping and advancing behavior change research and theories that originated outside of the IS discipline. In essence, IS serve a triple purpose in behavior change (Evans et al., 2022). IS can function as a means for digital behavior change interventions, act as an environmental influence that moderates behavior, and serve as a methodology for data collection for behavior change research within and outside the IS discipline. The role of IS for behavior change and its research is further expounded upon in the following paragraphs.

In today's digitally immersed world, a multitude of technologies has become an integral part of our daily lives (Evans et al., 2022). This encompasses tools like wearables, mobile devices, real-time displays, and biomarker sensors (Dallery et al., 2015). The advance-

ments of technology in the recent years gave rise to digital behavior change interventions that are now widely prevalent (Sjöklint, Constantiou, & Trier, 2015). A meta-review has highlighted that the trend in technology-based behavior change interventions gained momentum after 2001, with a notable surge accompanying the rise of smartphones (Taj, Klein, & Van Halteren, 2019). Behavioral aspects are relevant across various IS environments, including but not limited to crowdsourcing, recommendation and personalization systems, electronic marketplaces, augmented reality, and gamification (Goes, 2013). Digital behavior change interventions across the different environments use a broad spectrum of approaches, including gamification (Schmidt-Kraepelin, Toussaint, Thiebes, Hamari, & Sunyaev, 2020), nudging (Beermann, Rieder, & Uebernickel, 2022), feedback (Loock, Staake, & Thiesse, 2013), and virtual coaching (Weimann, Schlieter, & Brendel, 2022).

IS offer several unique advantages for promoting behavior change next to to their widespread availability and ease of replication and distribution. Unlike human persuaders, digital technologies can consistently deliver messages and gain access to private spaces, such as bathrooms, where human involvement may be unwelcome or unfeasible (Hermsen et al., 2016). Furthermore, digital technology allows for customization, enabling interventions to be tailored to specific needs and situations (Fogg, 2003), a pivotal capability for successful behavior change interventions. Nevertheless, it is vital to recognize and address the disadvantages of technology for behavior change and incorporate them into research endeavors. Digital technology can be more readily ignored or deactivated by individuals compared to messages delivered by human agents (Hermsen et al., 2016). Moreover, digital solutions are susceptible to being forgotten, misplaced, or lost, as illustrated by fitness wearables. While the benefits of IS for behavior change are substantial, it is crucial to acknowledge and mitigate these disadvantages.

Next to technology serving as a means of behavior change, the IS discipline also offer methodological advantages for behavior change research. IS researchers possess extensive experience in handling large sets of observational data, which hold immense potential for further advancing behavior change theories (Goes, 2013). Discrepancies between self-

reported and actual performance (Lichtman et al., 1992; Brener, Billy, & Grady, 2003) can be effectively addressed through the use of sensing data, which also allows for real-time analysis and feedback on behavior. The study of behavior change in is most effectively conducted in real-world field studies. Digital technology can address two common limitations of field studies: observer bias and the behavior changes associated with subjects' awareness of being monitored, which is especially relevant in research involving children. IS can be seamlessly integrated into existing routines and environments without disrupting normal behavior, facilitating controlled and precise interventions (Hermsen et al., 2016). Field experiments, complementing laboratory and observational data, leverage technology as an enabler for such studies (Goes, 2013).

Despite these advantages, the effective utilization of IS-enabled behavior change within the realm of IS research remains largely unexplored (Yoo, 2010). While research on the impact of digital behavior interventions is still in its infancy (Evans et al., 2022), it has seen an increase in recent years (Taj et al., 2019). However, many of the interventions lack scientific evidence to support their efficacy (Hermsen et al., 2016). Theory-driven designs of digital interventions are scarce. It is often the case that articles examining behavior change interventions fail to explicitly mention the behavior change technique on which their interventions are based (Taj et al., 2019). If articles mention behavior change techniques, they incorporate various behavior change techniques in one intervention without a comprehensive understanding of the underlying theoretical mechanisms (Spohrer, Fallon, Hoehle, & Heinzl, 2021). Thus, the determinants of effective IS based behavior change interventions are largely unexplored (Burton-Jones & Grange, 2013; Sjöklint et al., 2015).

Research on digital interventions is not limited to the IS discipline but spans across various disciplines, including computer science, psychology, and health, as the applications are diverse (Taj et al., 2019). The interdisciplinary nature of the topic necessitates knowledge and technology from different fields, yet the systematic integration of knowledge from various disciplines into interventions is currently lacking (Taj et al., 2019). To effectively

translate theoretical knowledge into innovative technology for behavior change, collaboration between behavioral and technological research is imperative (Taj et al., 2019). Close collaboration holds the potential for more effective digital technologies for behavior change, a greater societal impact, and a richer understanding of the intersection between behavior change and digital technologies (Taj et al., 2019).

2.3 The Role of Motivation

Motivation plays a pivotal role in driving behavior change, making it a central theme that threads through the diverse chapters of this dissertation. The following paragraphs delve into the concept of motivation within behavior change and IS research.

Similar to behavior change, motivation is inherently complex (Heimlich & Ardoin, 2008). It serves as a prerequisite for behavior change (Knittle et al., 2020) and acts as a driving force in designing effective interventions. It is important to recognize that motivation varies widely among individuals, and there is no single unifying motivator (Heimlich & Harako, 1994). Given the myriad of individual behavioral differences, individuals are motivated by different factors and possess varying capabilities when it comes to changing their behavior and habits (Heimlich & Harako, 1994). Understanding how motivation originates and is sustained, especially when the goal is long-term behavior change, is crucial (Achtziger & Gollwitzer, 2018; Prochaska, Redding, & Evers, 2008). This becomes particularly pertinent when dealing with daily, habitual activities (Kotsopoulos, Thanasis, Stamoulis, & Pramatari, 2017), such as health and sustainability behavior. One aspect of motivation of individuals is the drive to approach positive experiences and avoid unpleasant ones (Elliot & Covington, 2001; Higgins, 1997). We are inherently driven by the motivation to seek out experiences that promise pleasure while steering clear of those that bring discomfort.

To encourage desired behavior, IS interventions have to harness motivational principles. Examples of the investigation of motivation of individuals in IS literature can be found in various domains, such as writing reviews in e-commerce (Wright, 2010), con-

tributing to online communities (Federspiel, Schaffner, & Mohr, 2014), using fitness apps (Rockmann & Maier, 2019), and participating in crowdsourcing initiatives (Kaufmann, Schulze, & Veit, 2011). While motivation is an important concept in the context of IS research, further research is required to gain a better understanding of the intricate interplay between motivation and technology in the realm of behavior change. One aspect that should be further studied is the effect of motivation and self-efficacy on the impact of behavior change interventions. Literature postulates a positive effect of high initial states of motivation and self-efficacy on behavior change capabilities, which necessitates empirical validation (Hermsen et al., 2016), especially for digital interventions. As mentioned above for general behavior change theories, it is important to acknowledge that there might be differences that arise when applying motivation theories from other fields to IS interventions.

2.4 Research Gap

Reviewing literature on behavior change has unveiled the large untapped potential of the topic in the IS discipline. To fully harness the possibilities of IS in enabling a sustainable and healthy society through behavior change, further empirical research is imperative. The primary objective of this thesis is to provide empirically validated, impact-oriented insights into behavior change using IS.

As discussed in sub-section 2.1 and 2.2, there is a pressing need for additional research to craft more effective digital behavior change interventions. A pivotal question that remains unanswered pertains to the validity of insights garnered from behavior change interventions when applied to digital contexts: Can established behavior change theories effectively be applied to digital behavior change interventions? In sub-section 2.3 on motivation, the importance of motivation in behavior change has been underscored. There exists a necessity to unearth the motivations that drive individuals to change their behavior in domains, which could potentially be influenced by IS. Similar as above, it is crucial to explore which motivational theories from other disciplines can be effectively applied to

IS.

Leveraging existing behavioral research, the chapters in this thesis scrutinize behavior change in two distinct contexts. Chapter 1 and Chapter 2 focus on health behavior change among youg children. While there is a wealth of behavioral research on health, insights in the IS domain for children are rare. In the research articles of this dissertation, a digital behavior change intervention is introduced. This intervention is then used to ascertain the applicability of a specific theory, the MCT, in the IS context. Theoretical background and related work on children in IS is explored in Paper III, and for MCT in Papers V and VI. In Chapter 3, the emphasis shifts to sustainable behavior change among employees. While Green IS has become a well-established research field in IS (Seidel et al., 2017), this does not hold true for behavior change. The literature underscores the importance of expanding research on demographic and moderating factors that influence behavior (Hermsen et al., 2016). Understanding individual motivations and behaviors is essential for effectively addressing environmental behavior change (Heimlich & Harako, 1994). In an exploratory study (Paper VII), the motivation of train drivers is examined using PMT, a well-established motivation theory in the health context. The results serve as a critical enabler for designing successful IS interventions in the investigated context.

Research has emphasized that behavior change of individuals should not be studied in isolation but rather in the context of social structures, as those impact the success of behavior change (Loewenstein, Brennan, & Volpp, 2007; Thaler & Sunstein, 2008). Studying behavior in the context of social structures is, where IS and behavioral research can co-evolve, as IS environments increasingly encompass social contexts that demand consideration when investigating how IS operates (Goes, 2013). Both chosen application cases are situated within social contexts, day care centers, and the workplace.

3 Methodology

In order to accomplish the objectives of this dissertation, a variety of research approaches, research methodologies, and data analysis methods are employed. Theoretical frameworks distinguish between three research approaches: qualitative and quantitative approaches, and a combination of both known as mixed methods. Quantitative research approaches utilize numerical data to illustrate the relationships between independent and dependent variables. Conversely, qualitative research aims to describe and comprehend the underlying context surrounding these variables (Chen & Hirschheim, 2004). While this dissertation and its associated papers predominantly employ quantitative research approaches, they also incorporate elements of qualitative research. As a result, most papers rely on a mixed methods approach. The distinct research approaches translate into different research methodologies, which are discussed in detail in the following subchapters. Within each subchapter, the respective research method is described, highlighting the specific papers in which each method was employed (for an overview see Figure 1) and the corresponding data analysis techniques used to analyze the generated data.

3.1 Literature Review

The advancement of scientific knowledge is built upon the foundation of prior research. Literature reviews play a crucial role in understanding and identifying the current state of knowledge in a given field (Paré, Trudel, Jaana, & Kitsiou, 2015). There are two primary types of literature reviews: those that provide a theoretical background within a specific research paper, offering context and background to support the research question, and those that stand alone as research articles, summarizing the existing literature in a particular field (Paré et al., 2015).

The first type of literature review is present in each paper of this dissertation, providing the necessary theoretical background, context, and justification for the research question.

Additionally, Paper I and Paper III incorporate more extensive literature reviews. In Paper I, a literature review is utilized to conduct an economic impact analysis, while in Paper III, a literature review, combined with insights from one of the conducted field studies, is employed to derive conclusions about IS research involving children.

3.2 Field Experiment

When researchers aim to investigate cause-effect relationships, they often employ experimental research methods (Recker, 2013). Experimental studies involve manipulating an independent variable and examining its impact on the study participants. Experiments can be conducted either in a controlled laboratory setting or in real-world environments. Laboratory experiments offer high internal validity as the environment can be tightly controlled, although their external validity may be limited due to the artificial nature of the setting (McGrath, Martin, & Kulka, 1982). On the other hand, field experiments are conducted in natural settings, providing a more realistic context. While external validity can be steered by the choice of the participant pool, internal validity is contingent on the multitude of uncontrolled external factors in the real world setting (Karahanna, Benbasat, Bapna, & Rai, 2018).

Field experiments are characterized by specific features, including the definition and manipulation of the independent variable, the factorial design, the randomization, and the experimental design. The factorial design is defined by the number of independent variables that are examined and manipulated in an experiment (Broota, 1989). One-factorial, uni-factorial, and multi-factorial designs are possible. In the papers of this dissertation, a one-factorial design (Paper II) with two factor levels (control and treatment) and an uni-factorial design (Paper IV, V, VI) with one factor and more than two factor levels (control, several treatments) are employed. Experiments furthermore differ in their randomization technique. If participants in field experiments are randomly assigned to either the treatment or control group, the experiment is called true experiment. The field experiments conducted in this dissertation use quasi-experimental designs: natural groups (day

care center groups) are utilized as study groups. Experimental designs can be categorized as within-subject (each subject is assigned to each treatment condition at different points in time) or between-subject (each subject is assigned to one specific treatment condition) designs (Broota, 1989). The field experiments in this dissertation utilize a combination of within- and between-subject design by employing a Difference-In-Differences (DID) design, comparing the control and treatment group(s) across a baseline, intervention, and post-phase.

The two large-scale field experiments in this dissertation are conducted in day care centers. Working with children underscores the crucial advantage and indispensability of field studies in certain contexts. Conducting behavioral research in a laboratory setting would require instructing children to behave as though they were unobserved, a demand that is challenging if not impossible even for adults to fulfill. Both field experiments are enabled by the capabilities of modern technology, which include sensors and real-time displays. Considering the design choices mentioned, both field experiments in this dissertation are cluster-randomized controlled field trials, employing a DID design. Randomization happens on a day care center level rather than on an individual level.

The first field experiment and its results are presented in Paper II of Chapter 1. The second field experiment is detailed in Papers IV, V, and VI of Chapter 2: Paper IV provides the protocol for the field experiment, Paper V offers an in-depth exploration of the theoretical background in IS research in relation to the field experiment and associated hypotheses, and Paper VI presents the results. The collected data from both field experiments are analyzed using partial least squares regression.

3.3 Survey

Surveys, unlike experiments, do not involve the manipulation of independent variables. Instead, they aim at gaining insights into the "why, how, and what is happening" (Recker, 2013). The primary objective of surveys is to gather information about the phenomenon under investigation by surveying a large number of individuals or groups from the study

population (Recker, 2013). The goal of the survey is either exploratory, descriptive, or explanatory in nature. Exploratory surveys are conducted to gain a basic understanding of a phenomenon or subject of interest. Descriptive surveys seek to confirm specific behaviors, attitudes, etc., while explanatory surveys aim to test theories or understand the causal relationships between theoretical constructs (Recker, 2013; Pinsonneault & Kraemer, 1993).

In the context of the two field experiments of this dissertation (Chapter 1 and Chapter 2), surveys are employed to complement the experimental data by providing insights into the "why, how, what" aspects. In Paper II, surveys are conducted with parents of the day care children and day care staff as part of the field experiment. Similarly, in the second field experiment presented in Papers IV, V, and VI, surveys with parents are employed. In both cases, online questionnaires are utilized for data collection, which are subsequently analyzed using statistical techniques. The objective of the surveys in both field experiments is descriptive in nature, aiming to ascertain the results of the experiments.

In Paper VII, included in Chapter 3, an explanatory survey serves as the primary methodological approach. Surveys with train drivers across different regions are conducted to examine the relevance of a specific theory and test hypothetical causal relationships between different constructs. Structural Equation Modeling (SEM) is employed for data analysis. The goal of SEM is to empirically test the relationships among variables and determine whether the application of a particular theory is meaningful and aligns with the observed data (Hair et al., 2021).

3.4 Interview

Interviews can be conducted in either a qualitative or quantitative manner. While quantitative methods focus on specific phenomena through measurements, qualitative methods enable the consideration of context and the broader environment (Recker, 2013). Qualitative interviews are thus inherently exploratory in nature and aim to delve into broader

thematic areas. When following a quantitative research approach, interviews can be the research method of choice, if they are conducted in a structured manner. Structured interviews can serve as a data collection method for survey research, same as online questionnaires would do. Structured interviews are typically analyzed applying statistical measures, while qualitative interviews often rely on the researchers interpretation (Recker, 2013; Jackson, Drummond, & Camara, 2007).

Within the field experiments of this dissertation, conducted in day care centers, structured interviews are employed. On the one hand, children are interviewed as they are unable to fill out survey questionnaires. On the other hand, in the second field experiment, day care staff members are also interviewed (rather than being provided with an online questionnaire) to increase participation rates and obtain additional information about the perception of our field experiment through selected open-ended questions. Therefore, Paper II focuses on interviews with children, while the papers in Chapter 2 (Paper IV, V, VI) address interviews conducted with both children and staff members.

In Paper VII of Chapter 3, interviews with train drivers were conducted. The interviews were utilized as a qualitative research method to investigate the work environment and examine the factors that motivate and impact employees on a daily basis. The interviews served the purpose of eliciting initial sentiments from the interviewees to identify appropriate theories that could then be validated through a survey. Based on the interviews, questionnaires were developed for the survey employed and evaluated in Paper VII.

3.5 Observation

Observations have a long history in the scientific field (Denzin & Lincoln, 2011). In the case of direct observations, which are employed in this dissertation, the researcher acts as a passive and neutral observer who is not actively involved in the observed events. However, observations conducted by researchers are always influenced by their existing knowledge, which introduces the risk of subjective bias inheritance (Recker, 2013). To

mitigate this, observations can be limited to structured observation protocols, allowing for statistical analysis of the results rather than leaving the interpretation solely to the researcher.

Within this dissertation, the observation research method is applied in Paper IV, V, and VI of Chapter 2. The observations have a supportive role, aiming to corroborate the data collected from the field experiment, and they do not stand alone as independent outcomes. The observations here involve measuring and analyzing the number of steps in a standardized sequence of actions performed by children in day care centers.

4 Main Research Results

This section presents the primary findings of the papers encompassed within this dissertation. Each of the seven papers makes a distinct contribution towards addressing the research aim outlined in the introduction. The following subsections provide an overview of the key results obtained in each chapter and paper. A more comprehensive and detailed account of the findings are provided within the individual papers themselves.

4.1 Results from Chapter 1

This section provides a summary of the results obtained in the papers included in Chapter 1. The primary objective of Chapter 1 is to examine the potential of IS in enhancing health prevention behavior of children. Paper I motivates the topic by investigating the impact of infectious diseases on young children, highlighting the criticality of their prevention. One important measure for preventing infectious diseases is hand washing, the central use case explored in this dissertation. Paper II introduces an IS intervention to improve hand hygiene practices among children in day care centers. The paper furthermore outlines the experimental setup to test the intervention in the field and presents the results of the field experiment. Chapter 1 closes with Paper III which presents insights and lessons learned from conducting IS research with children using field experiments.

Paper I: Demonstrating the Economic Significance of Infectious Diseases in Children

The first paper (Graichen, 2022) of Chapter 1 delves into the economic consequences of infectious diseases among children in the day care center age group. Drawing upon existing literature and publicly available data sources, the research encompasses an economic impact calculation to estimate the societal costs associated with children with infectious diseases. The costs are categorized into three main components: direct healthcare, direct

non-healthcare, and indirect costs. Moreover, the presence of intangible costs is duly acknowledged. The breakdown of the costs per child is depicted in Figure 3. The findings of the cost estimation reveal that over three billion euros are expended annually in Germany alone due to infectious diseases among day care center-aged children.

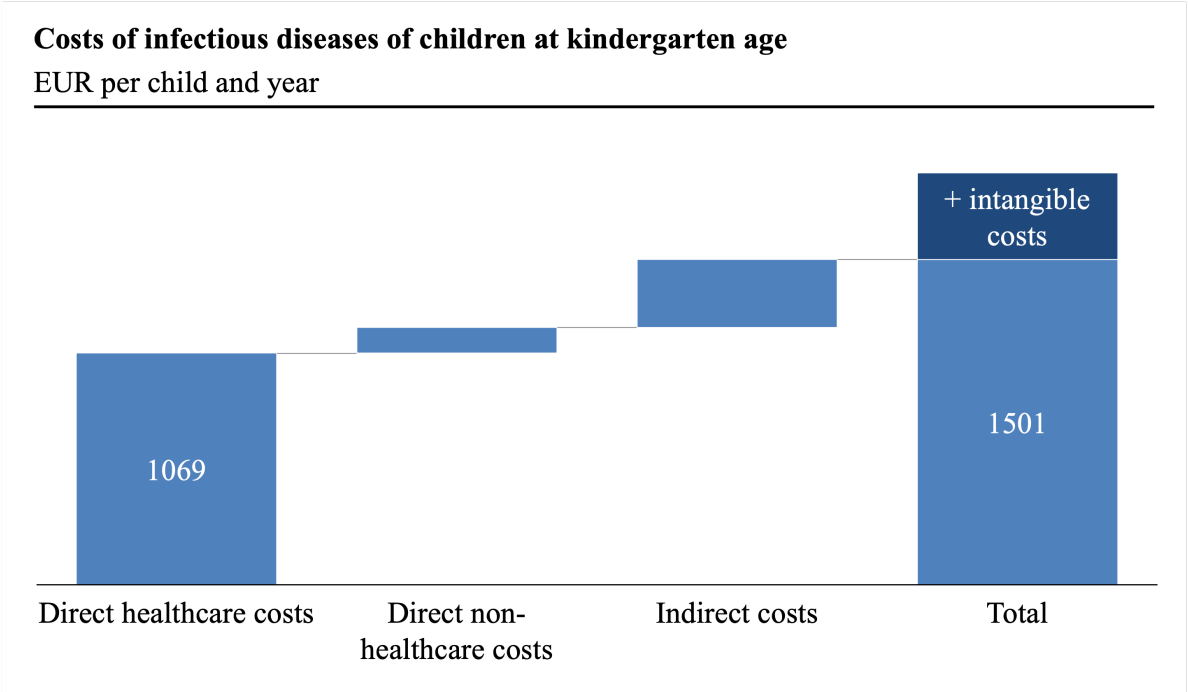

Figure 3: Overview of costs of infectious diseases of children at day care center age (Graichen, 2022).

The outcome of this paper presents a high-level estimation of societal costs, highlighting the relevance of the topic and urging both researchers and practitioners to take action. With infectious diseases on the rise, enrollment of children in day care centers at earlier ages, and the lack of intergenerational care support, the significance of addressing this issue becomes increasingly critical. It is imperative to raise awareness of the societal costs associated with sick children, stimulating discussions and promoting the search for effective solutions. By addressing this problem, we can strive towards creating an environment where both parents can actively participate in the workforce, fostering gender equality and providing equal opportunities for all.

Paper II: Investigating the Efficacy of an IS Intervention to Enhance Hand Hygiene Practices in Day Care Centers

Paper II presents a cluster-randomized controlled field trial, which explores the potential of a digital intervention to improve hand hygiene in day care centers. The study was conducted in four day care centers located in Finland and Germany, to implement and evaluate the intervention in a real-world setting. The intervention is designed around providing instructions and a symbolic reward displayed on a screen in real-time during hand washing. To ensure transparency and rigor, the field trial was pre-registered on *clinicaltrials.gov*. The research followed a DID design, involving data collection during the two-and-a-half-week baseline phase, four-week intervention phase, and two-week post-phase. The day care centers were allocated to the treatment and the control group using cluster randomization, with one day care center in each country assigned to the treatment group and the other one to the control group. Data collection involved the use of sensors to record all hand washing procedures in the participating day care centers. To maintain ethical standards, individual authentication of children was not deemed appropriate. Therefore, all hand washing activities were recorded without establishing a connection to individual children. Additionally, interviews were conducted with children by researchers who were not directly involved in the project, along with surveys administered to parents and educators. It is important to note that participation in the surveys and interviews was voluntary, and informed consent was obtained from parents and children prior to the start of the experiment.

The dataset comprises 13,466 hand washing procedures, collected between April and July 2021, involving an average of 127 children. The sensor data analysis, presented in Figure 4, reveals an increase in soaping time by 5.30 seconds (+62%, $p<0.001$) in the intervention phase in the treatment group. The integration of interviews and surveys with the sensor data provides a more comprehensive understanding of the system's utility, confirming its effectiveness in promoting improved hand hygiene practices and outruling potential negative effects that might not be conceivable in the sensor data.

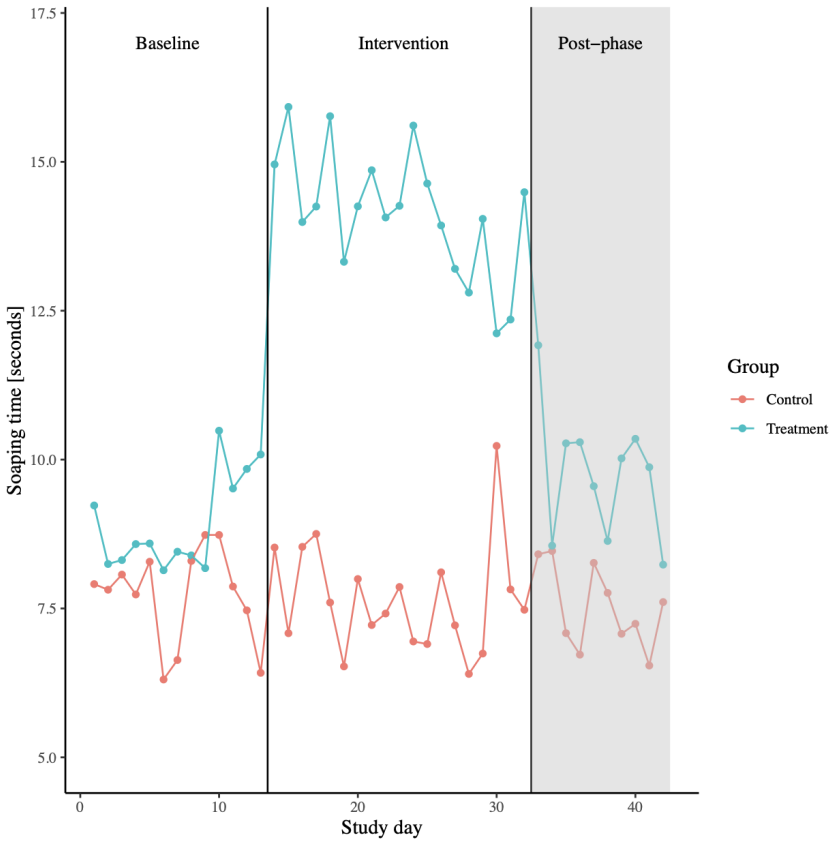

Figure 4: Development of soaping time over time, aggregated for all four day care centers (Source: Paper II).

The study demonstrates how digital interventions can be designed and how experiments can be conducted to assess these interventions. Both of these aspects are crucial prerequisites for testing the validity of behavior change theories in the IS field, as done for MCT in Chapter 2 of this dissertation. The study furthermore demonstrates the successful implementation of real-time instructions and symbolic rewards within a practical digital solution, which effectively guides and supports children in performing everyday tasks that often lead to conflicts between caregivers and children. With a deliberate focus on hand washing for children, the study recognizes the significance of hand hygiene for children's health, considering their vulnerability and the substantial impact of sick children on their parents' lives. Expanding the application of our digital intervention to other tasks commonly performed by children, such as teeth brushing, presents an influential approach to modern-day education. Given the proven effectiveness of real-time

feedback on adults as well (Tiefenbeck et al., 2018), our digital system, featuring modified screen animations, could also enhance hand hygiene practices among adults. Moreover, the adaptability and transferability of our intervention make it applicable to settings like hospitals or nursing homes, providing protection to vulnerable groups for whom infections pose life-threatening risks.

Paper III: Introducing Considerations for Successful IS Research with Children

Paper III (Graichen & Staake, 2023) delves into the unique characteristics of children and provides guidance for successful IS research involving children. The paper employs a literature review and builds upon the insights from the field experiment that is described in Paper II. The field experiment reveals that challenges associated with conducting research involving children are distinct from those encountered in studies with adults.

The influence of IS is no longer limited to organizations but has permeated into the daily lives of individuals. In light of this, it is crucial for the IS discipline to not only involve adults in their research but also children. The key insight derived from the investigation here is that there is no general truth regarding behavior of children (Barker, Weller, 2003) and research projects with them, as each study is unique and influenced by differences in age groups and socialization processes of the children. However, there are guideposts that IS researchers, particularly those with limited experience in researching with children, can follow to achieve success. These guideposts can be summarized into the categories ethics, design, methodology, analysis, and result interpretation. Ethically, concepts from other disciplines need to be expanded when conducting IS research with children due to the ability of IS to "invisibly" collect sensitive data on a large scale. The design of experiments should draw upon experiences from the field of Human-Computer Interaction and Child-Computer Interaction, which emphasize the importance of children as valued design partners. Methodologically, IS offers new potential for field studies with children to gather real-world data. However, result analysis requires particular caution to avoid

interpreting children's actions and statements through the lens of adults.

Overall, there are several considerations that must be taken into account to conduct successful IS research with children. These considerations are vital for establishing the significance of IS research with children and ensuring that it receives the recognition it deserves on the IS research agenda.

4.2 Results from Chapter 2

This section presents the outcomes from Paper IV, V, and VI, constituting Chapter 2. Collectively, Chapter 2 underscores that Health IS can provide empirical insights to advance behavioral theories, particularly motivation theory, within the context of children. Each paper of this chapter revolves around one common field experiment aimed at scrutinizing hand washing behavior among young children. The field experiment essentially extends the groundwork laid by the field experiment in Paper II, which introduces an IS intervention to enhance hand hygiene in day care centers and assesses its feasibility. The first paper of Chapter 2, Paper IV, serves as a study protocol, comprehensively describing the study's objectives, methods, and scope. Paper V delves deeper into the methodology and objective of the field experiment in light of IS research, i.e., the investigation of the impact of the IS intervention on children's motivation. While Paper V emphasizes the theoretical framework, corresponding hypotheses, and the design of the field experiment, Paper VI encompasses detailed results of the field experiment and their discussion.

Paper IV: Designing an Experiment for Behavioral Field Research with Children to Investigate Behavioral Theories

Paper IV (Dangis et al., 2023) presents a protocol article for the second field trial. Protocol articles are a vital component to ensure the credibility of a field trial (Turner, 2013; Chow & Chang, 2008) and reduce publication bias (Hermsen et al., 2016). The field trial presented in the protocol article employs a slightly modified and enhanced version of the IS artifact assessed in the initial field experiment in Paper II. While the primary

objective of the study remains unchanged – demonstrating the potential enhancement of hand hygiene among young children to mitigate illnesses – the second field experiment carries significant theoretical objectives that profoundly shape its design. Essentially, the study pursues four primary goals: assessing the influence of the IS intervention on hand washing behavior and sickness occurrences, exploring the impact of the intervention on self-efficacy, and investigating its influence on motivating children to engage in the desired behavior.

Conducted between May and June 2022, the field experiment encompasses 3 day care centers in Turku, Finland. The study adheres to the CONSORT guidelines for cluster randomized controlled trials (Campbell, Piaggio, Elbourne, Altman, & CONSORT Group, 2012). Structured as a four-arm trial, comprising a control group and three distinct intervention groups, the study is divided into three phases – baseline, intervention, and post-phase – supplemented by a twelve-month follow-up period. The study is conducted within day care centers, with each center treated as a cluster to minimize cross-contamination between the study groups.

Figure 5 provides an outline of the experimental design described in the study protocol (please note that the figure originates from Paper VI to represent the experimental design that was actually used in the field experiment). In the baseline phase, children within each day care centers maintain their customary hand washing routine, supported by newly installed automatic faucets and soap dispensers, outfitted with technical measurement and transmitting devices. Midway through the baseline phase, an educational video on proper hand washing techniques is presented to all children to ensure uniform theoretical knowledge among participants. The control group is not exposed the IS intervention and remains intervention-free throughout the study. In the intervention groups (instruction and reward group), tablets are installed above washbasins at the commencement of the intervention phase, displaying two versions of the digital intervention in the intervention phase (see Figure 5). Children in the instruction group receive hand washing instructions, while those in the reward group, in addition to instructions, receive digital rewards if

they utilize soap during hand washing and exhibit adequate soaping time in front of the tablet. The post-phase sees the deactivation of screens for the instruction and part of the reward group, while the other part of the reward group continues to receive hand washing instructions without rewards on the displays.

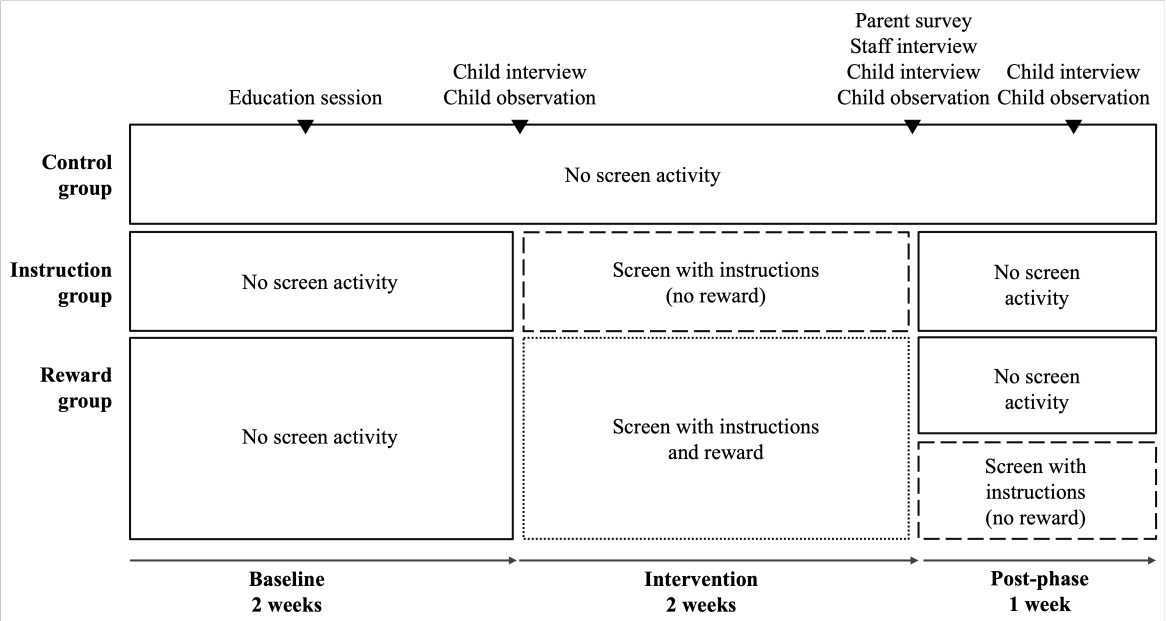

Figure 5: Experimental design of the four-arm cluster randomized controlled field trial (Source: Paper IV).

The comprehensive measurements of the hand washing procedures, facilitated by technical devices, is further complemented by on-site hand washing observations, interviews with children and staff, and a parent survey. A twelve-month follow-up seeks to ascertain any potential impact on the children's sickness occurrences as reported by the day care center management. The investigation of the intervention's influence on sickness days and self-efficacy of the children constitute separate research papers, which are not considered further in this dissertation. The examination of the intervention's effect on hand washing behavior and children's motivation falls within the scope of Paper V and VII, whose outcomes are summarized in the subsequent sections.

Paper V: Exploring Behavioral Theories for Investigating Effects of IS Interventions on Motivation of Children

Paper V (Graichen et al., 2022) elucidates the field trial outlined in the protocol article within the framework of IS and behavioral theories. The overarching objective is to assess the impact of digital rewards on children's motivation to alter their behavior. Paper V outlines the theoretical underpinnings and results in a comprehensive study methodology, delineating what needs to be measured and how it should be measured to contribute to the advancement of behavior change theory in the field of IS research.

In this context, Paper V introduces MCT. The theory posits that the effect of rewards on well-liked activities, specifically intrinsically motivated activities, can potentially be negative. The rewards have the potential to diminish the motivation to engage in the activity without a reward, thus driving motivation below its original level (?, ?; Promberger & Marteau, 2013). The existence and conditions of motivation crowding have been extensively debated in different research disciplines. IS, equipped with the capability to administer digital rewards, hold immense potential in influencing behavior with rewards. However, the role of motivation crowding in the context of digital rewards remains largely unexplored, forming the subject of investigation within this study, particularly in relation to children and hand hygiene.

The primary outcome measure utilized to examine motivation crowding in this field experiment is the motivation to wash hands, which, in line with existing literature (?, ?), is gauged by the duration spent engaging in the activity (here measured as soaping time). The experimental design of the field study (as introduced in the preceding section concerning Paper IV), encompassing the three distinct intervention groups, facilitates the formulation of several hypotheses pertaining to motivation crowding. Leveraging the existing body of literature on motivation crowding, the hypotheses articulated in the paper posit the following: the provision of digital instructions during hand washing augments task performance. The presentation of subsequent digital rewards serves as a positive moderator for task performance. In order to scrutinize motivation crowding, the evolu-

tion of task performance during the post-phase, subsequent to the removal of rewards, is crucial. The hypothesis in this context conjectures that, upon the cessation of instructions, there will only be a marginal decline in task performance. However, when rewards are withdrawn, a pronounced drop in task performance is anticipated, potentially falling below the baseline performance, indicative of the occurrence of motivation crowding. The ensuing subsection outlines the outcomes of the specific facet of the field study linked to motivation crowding, as presented in Paper VI.

Paper VI: Providing Empirical Evidence for Increased Task Performance Enabled by IS Intervention Working with Rewards

Paper VI presents the outcomes of the field experiment, whose protocol is detailed in Paper IV, and who's theoretical framework and objectives in relation to the IS discipline are outlined in Paper V. Within the field experiment, data was gathered from a total of 254 children. Close to 6000 instances of hand washing procedures (including water and associated soaping actions) were recorded by the technical devices. Additionally, there were 279 visual observations of hand washing processes conducted by researchers, 116 interviews with children, 8 interviews with day care center staff, and 53 parent surveys. The conjunction of quantitative data from technical measurements and observations and qualitative data from interviews and surveys allows for valuable insights into motivation crowding concerning digital rewards in children.

The impact of the intervention on hand washing motivation is illustrated in Figure 6, depicting changes in mean soaping time across experimental groups. The effects within the instruction group align directionally as postulated (as per the hypotheses listed in Paper V): soaping time sharply increases while instructions are shown. Although the soaping time diminishes once the instructions are removed, it remains significantly above the baseline level. Similarly, the reward group exhibits a comparable trend, yet the soaping time is consistently higher both during the intervention and post-intervention phases. In the intervention phase, the soaping time in the reward group increases on average by 63%,

in contrast to 19% during the post-phase. Correspondingly, for the instruction group, the figures are 49% and 0.01%, respectively. The intervention's positive effect is further supported by observations, which reveal statistically significant increases in the number of distinct soaping movements performed by the children while instructions and rewards are provided and thereafter. Also the survey responses from parents in the intervention group report an enhancement in hand hygiene of the children.

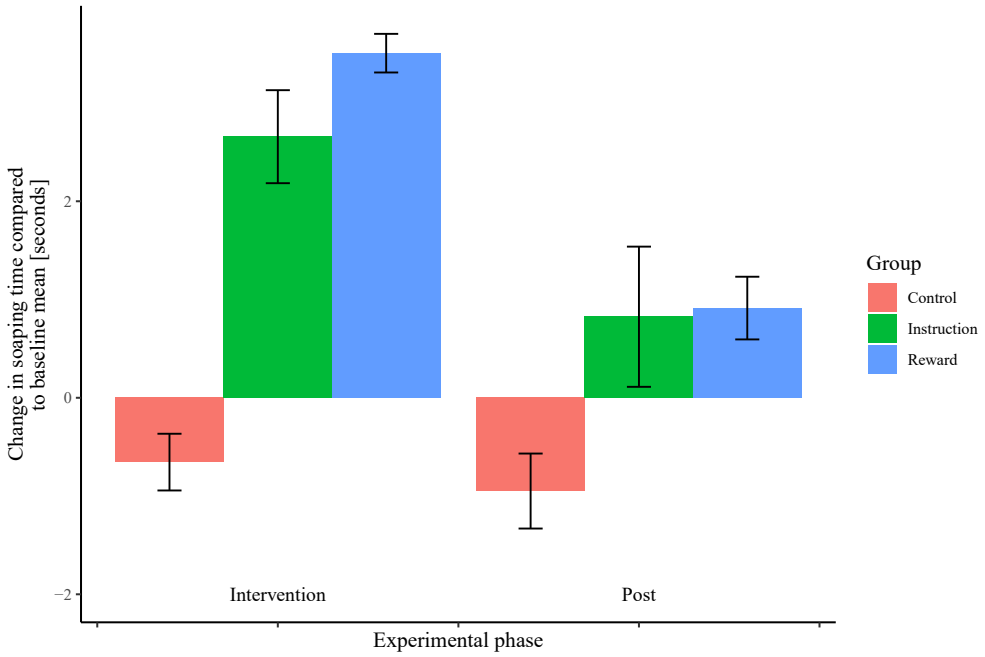

Figure 6: Change in mean soaping time in intervention and post-phase compared to baseline (Source: Paper VI). Note: Bars indicate the mean difference in soaping time per experimental group compared with the mean of the baseline phase. Error bars represent mean ± SEM.

The outcomes of the field experiment provide empirical evidence that digital rewards can contribute to the successful acquisition and adoption of health behavior among children. In the presented setup, indications of motivation crowding were not identified. Instead, the increase in task performance in the post-phase suggests that the motivation, heightened by digital rewards, continues to persist even beyond the reward period (at least to some extent). Therefore, IS interventions have the potential to make a significant contribution to motivating healthy behavior among children through digital rewards. This

finding is an important theoretical contribution to MCT, paving the way for an increased utilization of digital rewards for behavior change.

4.3 Results from Chapter 3

In the following, the results of Paper VII from Chapter 3 are summarized. The overarching goal of Chapter 3 is to highlight how IS can contribute to fostering environmentally sustainable employee behavior in the workplace. Paper VII takes an important step in this direction by examining the motivation of employees to engage in sustainable behavior and to utilize Green IS.

Paper VII: Investigating Motivation for Energy Efficiency and Green IS usage of Employees

Paper VII addresses the motivational affordances of transport employees to save energy on the job. Transport employees have the potential to impact CO_2 emissions through their day-to-day behavior at work. The study investigates the motivational affordances of employees at a large European railway company. Qualitative, in-depth, face-to-face interviews were conducted with ten transport employees to gather first insights. These insights were used to develop a survey, which examines the environmental behavior and perceived Green IS usefulness of employees based on PMT. The PMT, originally developed to explain health-related risk behavior (Rogers, 1975), has just started to find applications in the domain of slow environmental risks, such as climate change (Bockarjova & Steg, 2014). The PMT measures the protection motivation decision, here the decision to engage in energy-efficient behavior, using six dimensions: severity, rewards, vulnerability, response efficacy, costs, and self-efficacy. The study further explores how employees' protection motivation decisions relate to their perceptions of the usefulness of Green IS. The model is depicted in Figure 7.

A total of 105 active train drivers from the railway company participated in the online-based survey questionnaire. The survey results were analyzed using SEM based on the

Figure 7: Path coefficients for structural PMT model in the context of energy-efficient driving behavior and Green IS usage (Source: Paper VII).

partial least squares path modeling technique. This approach is appropriate for testing theories at early stages (Fornell & Bookstein, 1982), as is the case with the PMT in the context of slow environmental risks. The evaluation of the measurement model demonstrates the fulfillment of all quality criteria, allowing for the evaluation of the structural model. The results are shown in Figure 7. An R^2 value of 0.59 is achieved, indicating that 59% of the variance is explained in the endogenous constructs. Assuming a significance level of 5%, all relationships except one (from self-efficacy to protection motivation decision) are significant (see Figure 7). Response efficacy, with a coefficient of 0.483, has the strongest impact on the protection motivation decision and is highly significant ($p<0.01$). Furthermore, the relationship between the protection motivation decision and the perceived usefulness of Green IS is positive and exhibits a strong effect, aligning with our initial hypothesis.

The study demonstrates that the PMT is a suitable theory to explore the motivational affordances of employees in the domain of slow onset environmental risks. This extends Green IS theory by incorporating the PMT, providing valuable insights into the motivation behind the use of Green IS. The findings from applying PMT here highlight the significance of the perceived severity of climate change (as measured by the questionnaires based on PMT) that is accelerated by emissions in the transportation sector, as well as the importance of response efficacy in fostering employees' urgency to act in a climate-

friendly manner. Emphasizing the severity of climate change and response efficacy in the work context can thus be an effective strategy for promoting environmental sustainability among employees. Green IS can serve as a means to pursue this strategy in organizations at scale and at a low cost. Our results inform the design of Green IS initiatives aimed at promoting sustainable employee behavior. Overall, this study is the first to investigate the motivational affordances of employees in the context of slow-onset environmental risks and IS, providing valuable insights for research and practice in this area.

5 Discussion

The objective of this cumulative thesis is to explore the potential of IS in promoting sustainable and healthy behaviors among individuals. The Introductory Paper sets the foundation by presenting the motivation behind the research, the theoretical framework, an overview of the methodology employed, and a summary of the findings from the included research papers. Prior to concluding the Introductory Paper, the fifth section provides a general discussion of all chapters of this thesis, including overall implications for both theory and practice as well as limitations and future research directions. The in-depth discussions of the findings for each individual research paper are presented within the respective papers themselves, which can be found in Chapter 1, Chapter 2, and Chapter 3.

5.1 Contributions and Implications

While the individual chapters of this dissertation address different research questions, they still yield common contributions. The synthesis presented here aims to consolidate the collective outcomes and draw meaningful insights for researchers and practitioners in the field and beyond. The following section summarizes the key contributions of the thesis and their implications.

Improving health and sustainability behavior with IS interventions

The dissertation demonstrates that changing or learning everyday behavior can be challenging, but is achievable with the help of IS. Chapters 1 and 2 provide evidence from the field, that IS interventions can improve everyday health behavior of children. The intervention improves hand hygiene not only for individual children, but for entire day care centers as showcased in the field experiments. Chapter 3, on the other hand, enables behavior change of employees by exploring their motivational affordances to act green.

While the effect of an IS intervention still has to be explored in this context, the work here serve as important groundwork for subsequent experiments, as the design of interventions should closely relate to the motivation of the target group.

Overall, behavior change interventions relying on IS offer several advantages. Due to the low costs of sensors and connected devices, IS interventions are cost-effective and highly scalable. With those characteristics, IS interventions can be employed in public settings to enable reaching marginalized groups. The digital hand washing intervention for example, can be employed not only in day care centers, but also schools, and other public buildings. Similarly, they can be implemented in office buildings and restaurants to promote behavior change among employees. Often, digital behavior interventions can be implemented on existing devices, making scalability even easier. For instance, a potential digital intervention for transport employees could be integrated into existing driver assistance systems. The success of IS to promote behavior change and its relevance is underscored by frequent media coverage of the topic, exemplified by a press release of our *Candy* project (Graichen, Stingl, & Staake, 2021).

Promoting behavior change among children with IS interventions

Chapters 1 and 2 present a practicable solution on improving hand hygiene of children and provide evidence for their effectiveness. The practical implications of our research are substantial, as they help mitigate the negative consequences of illness in children, not only for the children themselves but also for their families and society at large.

The effective promotion of health behavior among children through the presented intervention furthermore highlights the potential of IS research in the context of children. Children have been underrepresented in IS research to date, despite the substantial differences between adults and children in terms of behavior and technology use. Conducting research with children can be challenging, as field experiments come with their own set of considerations, particularly concerning ethics and privacy. Nevertheless, children, with their unique characteristics, deserve a prominent place on the IS research agenda. In-

corporating child behavioral research expands the relevance of IS research and suggests that the IS research agenda should encompass a wider range of target groups and topics, ensuring that certain groups are not excluded.

The relevance of the results obtained in the field experiments extend beyond the domain of children's hand hygiene. Interventions working with digital rewards have applications in various activities and for diverse target groups. They are for example used for adults in online product reviews (Khern-am nuai, Kannan, & Ghasemkhani, 2018). The broad applicability of digital rewards underscores the importance of our findings and the general need to extend the knowledge about the effectiveness of digital rewards in the IS discipline.

Conducting large-scale field experiments with the possibilities of IS research

Traditionally, behavioral research has heavily relied on laboratory and survey research (Whitley & Kite, 2013). Recent advancements in technical equipment and their increasing affordability provide IS researchers with the opportunity to collect and analyze vast amounts of data. The utilization of sensors allow researchers to capture real-world behavior in a natural setting. Technology furthermore enables large-scale field experiments. The data of those field experiments can yield valuable insights into human behavior and the effectiveness of IS interventions.

However, conducting field research and behavioral studies in the IS domain also presents new challenges and requirements. One such requirement is the implementation of a protocol article, which is a relatively new concept in the IS field but important for methodologically sound experimental field studies. This dissertation includes a protocol article for the field experiment of Chapter 2. The protocol article, Paper IV (Dangis et al., 2023), is conducted and published in a reputable outlet, namely PLOS ONE.

By embracing field research, this dissertation contributes to the expanding landscape of IS research methodologies. It highlights the importance of conducting studies in real-

world contexts, enabling researchers to gain a deeper understanding of the complex interplay between technology, human behavior, and societal outcomes.

Acquiring behavioral insights with field research and mixed methods

When survey and interview methods are not sufficient to empirically validate behavioral theories, field experiments can complement traditional methods and provide powerful insights. However, only few experiments can be easily translated into real-world settings. If field research is applicable, it offers unique advantages and insights, particularly in the domains of health and sustainability.

Surveys and interviews alone are often insufficient to capture actual behavior, and this limitation is particularly pronounced in the context of moral obligations to society (Allcott & Mullainathan, 2010). The limited validity of interviews is especially pronounced in the context of young children. Interviews are limited in capturing valid statements about actual behaviors, and questionnaires may not be suitable at all for children due to their lack of reading skills. Conducting laboratory experiments on behavior with children also has limitations, as children as well as adults may behave differently under observation. In contrast, sensor data collection overcomes these limitations by collecting data in real-life situations, independent of direct observation. While field experiments alone offer significant value, they are particularly powerful when combined with interviews and questionnaires, as they complement each other and enhance the overall interpretability of the measurements. A mixed methods approach allows for a more comprehensive understanding of behavior in general and of children in particular.

In Chapters 1 and 2 of the dissertation, two field experiments with children are conducted, employing a mixed methods approach. The primary focus is on field experiments with sensor data collection, which are supplemented by survey, interview, and observation research. The advantage of using sensor data is that it allows for the observation of all children in the day care centers, whereas interviews and surveys are limited to those children and parents who explicitly provide informed consent for participation in the experiment.

This can introduce volunteer selection bias in questionnaire-based research.

In Chapter 3, specifically in Paper VII, questionnaires are utilized to assess intended IS usage. Here, volunteer selection bias and limitations in capturing actual behavior present a challenge. Despite efforts to reduce volunteer selection bias (e.g., by distributing surveys through team leaders of the employees instead of an unknown third party), it can only be mitigated to a certain extent. Also here, a mixed method approach including field experiments would be valuable for measuring intended IS usage and capturing data from as many colleagues as possible, complementing the questionnaire-based approach.

Providing empirical evidence and elevating behavior and motivation theories in the context of IS

This dissertation offers empirical evidence for the application and expansion of behavior and motivation theories within the context of IS across two distinct application domains. In both domains, existing theories have been adapted and extended, departing from the conventional laboratory-based survey approach to behavioral research embracing real-world field studies facilitated by IS. This shift not only benefits the realm of behavioral research but also underscores the significance of behavioral research within the IS discipline.

Behavior change is closely tied to motivation, and behavior interventions using rewards can potentially have measurable negative side effects on this motivation as postulated by MCT. However, our research delivers empirical evidence suggesting that digital rewards can be effective without inducing the mentioned motivation crowding effect. While few prior studies have explored the application of MCT in the IS field, these examinations have typically taken place within artificially-induced settings (Wu, 2019; Tong, Wang, & Teo, 2007). Our study, on the other hand, uniquely demonstrates how MCT can be systematically investigated in real-world settings, not only adding to the understanding of MCT in IS but also setting a valuable precedent for future research in the field. Our results offer insights into the conditions under which motivation crowding may or may

not occur in the context of digital behavior change interventions. Specifically, digital rewards for health behavior can effectively prompt behavior changes of children. While MCT postulates that the digital rewards might have negative effects on motivation, our field experiments showcase that those are offset by the positive effect of the rewards on task performance in the context of hand washing in day care centers.

Furthermore, we illustrate that PMT can effectively predict and explain environmentally sustainable behavior among employees, as well as their self-reported IS usage. PMT, traditionally applied to health contexts, is extended to address environmental risk perceptions and their correlation with intended IS usage. This showcases how theories developed in other domains can be transferred and effectively employed within the IS field.

In summary, this dissertation not only provides concrete insights into specific applications related to health and sustainability but also serves as a testament to the ability of the IS discipline to empirically validate and elevate existing behavior change theories. Consequently, IS researchers studying behavior change are encouraged to draw inspiration and guidance from theories spanning different disciplines when embarking on their own investigations. While this interplay between theories from diverse areas can enrich IS research, IS can also contribute to the advancement of theories.

Explaining multifaceted human behavior by integrating theories from various disciplines

The thesis incorporates theoretical knowledge from diverse research fields, including behavioral economics, social science, education science, psychology, and IS. By integrating theories from different disciplines, e.g., MCT and PMT, the aim is to comprehensively understand the multifaceted nature of human behavior. Typically, theories on individual behavior originate within specific research fields and for specific domains. In the context of this thesis, Paper VII exemplifies how the PMT, which originated in psychology as a theory of health behavior, can be adapted and applied to investigate sustainability behavior, particularly in the realm of Green IS usage. Papers V and VII, on the other hand,

demonstrate how MCT can be successfully utilized in IS research, despite its origin in psychology and economics. This highlights an important insight: theories for studying behavior should not be confined to the specific domain from which the behavior originates. Instead, it is crucial to expand the scope and search for relevant theories from different research fields and domains. This is particularly relevant for IS research, as the study of behavior in this field is still emerging (Goes, 2013), and the existing set of behavioral theories may not be comprehensive enough.

Expanding the relevance and accessibility of IS research through interdisciplinary approaches

Related to the previous point, the integration of research approaches, methods, and knowledge from different fields and geographies is a logical approach that can yield valuable insights. This integration can be achieved through interdisciplinary collaboration, which fosters the emergence of new research approaches and ideas. Given the diverse range of disciplines that study health, sustainability, and behavior, there is considerable potential for overlap and mutual learning. Embracing this interdisciplinary perspective not only enhances the visibility and accessibility of research within a larger research community but also increases its value for practitioners. The lack of collaboration between disciplines is considered a key reason why behavior change insights, despite high research activity, remain limited (Duckworth & Gross, 2020). Scientists with diverse backgrounds conduct research on behavior change, yet their findings are not effectively interconnected and are predominantly communicated through journals and conferences specific to their respective disciplines (Duckworth & Gross, 2020).

The commitment to interdisciplinary collaboration is evident in this thesis, as Chapter 1 and Chapter 2 are based on projects with Nursing Science researchers from Finland. The papers included in this dissertation have been published in reputable IS research outlets (Graichen et al., 2022), as well as in scientific publications outside the IS field (Dangis et al., 2023), making them relevant and accessible for a broad community of researchers and

practitioners, and garnering attention from the public, as press coverage of the project shows (Graichen et al., 2021).

5.2 Limitations and Research Outlook

Despite all efforts, the presented contributions come with certain limitations which merit careful consideration. The subsequent paragraphs outline the main limitations across the chapters, related to external validity in the context of field experiments, volunteer selection bias, and time frame constraints. The section closes with a research outlook, presenting promising future research avenues.

Conducting research in the field, as highlighted in Section 3, requires careful evaluation, as external validity is contingent upon exogenous factors. In Chapters 1 and 2, the experimental setup includes data collection in different day care centers of different neighborhoods and countries to increase generalizability. However, similar to the majority of evidence in literature regarding behavior change techniques and digital interventions, data has been gathered primarily from residents of high-income countries. In the case of Chapter 3, the scope of the survey field study is limited to employees in the transportation sector in Germany, which may restrict the transferability of findings to other industries, other countries, and employees of other industries, given that behavior is highly context-dependent.

Additionally, volunteer selection bias can be a pertinent issue in field studies. The measurements performed by technical equipment in the day care centers (field experiments in Chapters 1 and 2) were not affected by volunteer selection bias since data was collected from all children in the day care centers, thus enhancing the generalizability of the findings. However, interviews and surveys were conducted only with those children and parents who voluntarily signed up for participation. In the survey field study in Chapter 3, employees participated based on their own interest without additional incentives, making it likely that the survey results do not represent the entire employee population. As the study

was exploratory in nature, the effect of the volunteer selection bias could be leveled out by careful result interpretation.

Another limitation, that all three field studies have in common are time frame constraints. In Chapters 1 and 2, longitudinal data was collected over several weeks, marking a significant strength of the field experiments in comparison to existing studies in literature. However, to explore whether genuine habit formation took place, field experiments with a much longer duration are needed. In Chapter 3, the survey field study gathered data from individual employees at a single point in time. Although it's unlikely that employees change their general environmental attitudes from one day to another, the possibility of certain day-specific effects cannot be ruled out.

The research conducted in Chapters 1 and 2 evaluates a digital behavior change intervention and associated behavioral theories in the context of health and children. While the field experiments investigating hand hygiene clearly showcase the effectiveness of the digital intervention among children, there exist numerous avenues for further exploration beyond the extension of the research duration previously mentioned. The second field experiment demonstrates that motivation crowding does not manifest in the presence of digital rewards offered by the implemented digital behavior change intervention. This indicates that digital rewards can serve as a tool for influencing children's behavior positively. Nonetheless, it remains to be ascertained whether this outcome is contingent upon the specific conditions under consideration here, namely, the hand washing practices of young children in day care centers, or if it holds true in different scenarios. The digital intervention, with minor adjustments, exhibits substantial potential for investigating behavior in diverse populations (including older children, adults, and seniors) and within varied settings (such as schools, restaurants, and nursing homes), where hand washing and the exploration of behavior change is also highly relevant.

Chapter 3 predominantly centers on research concerning the motivational factors influencing transport employees' adoption of energy-efficient practices and Green IS utilization. The transportation sector, which already collects a wealth of data, offers substantial

potential for the implementation of digital behavior change interventions for energy efficiency, as they can be integrated into existing systems. Subsequent research endeavors should delve into the development of digital behavior change interventions rooted in the motivational factors identified in this study. Future research should furthermore extend the investigation of motivational factors to other use cases and industries in order to be able to improve behavior change interventions across domains.

It's worth noting that the theories studied in these experiments represent only a small selection of behavior change theories. Future IS research in this area has much ground to cover. The primary focus here was to motivate individuals to change their behavior and harness the potential of IS behavior change interventions for a healthy and sustainable future. However, behavior change is just one part of the equation, as IS can contribute to other aspects of health and sustainability, such as efficiency improvements of technical systems and processes. Regardless of the approach taken to solve the challenges of our time, interdisciplinary collaboration remains imperative. This dissertation serves as a demonstration of both the necessity and the success of such collaboration.

6 Conclusion

In conclusion, this thesis has highlighted the growing importance of IS in our lives and their potential to address the pressing challenges we face. While previous IS research has focused on topics such as the economic impact of technology and its acceptance, the field has now shifted towards exploring how IS can contribute to solving the pressing problems of our time, specifically in the domains of health and sustainability. In both domains, the promotion of preventive health measures and energy-efficient behaviors was initially perceived as low-hanging fruit due to seemingly minimal investments and technological advancements required. However, these areas have proven to be complex, necessitating a multidisciplinary approach that combines insights from behavioral economics, social sciences, education sciences, psychology, and IS.

By integrating theories from diverse disciplines and adopting an IS perspective, this thesis has demonstrated the added value of such an interdisciplinary approach through two experimental and one survey field study. The findings have underscored how IS can influence individual behavior and facilitate healthier and sustainable choices. This holds true for two distinct groups: children, whose intentions and decision-making processes are often less explicit and transparent, and employees, who may have clear intentions but struggle to bridge the gap between intention and actual behavior in their professional lives.

Collaborations with researchers from different fields and countries, various industry partners and practitioners played a pivotal role in shaping the design of the experiments and contributed to the outcomes of this dissertation. The collaborative effort ensured access to a broad scientific knowledge base and enhances the relevance of the findings for researchers and practitioners. It is essential to recognize that the complex challenges of our time cannot be solved by any single discipline, scientific endeavor, or practical application alone.

While the media often portrays daunting images and numerous steps still lie ahead of

us to provide every child with a healthy life on a healthy planet, this thesis has demonstrated that we are not powerless and can achieve a great deal through interdisciplinary research. The interest in the findings of this thesis, the strong commitment of the involved collaborators, and the advancements made by researchers across scientific disciplines and practitioners collectively foster optimism that humanity can effectively address the self-inflicted challenges and secure a prosperous future for our planet. This thesis has demonstrated that IS has great potential to contribute to this important endeavor.

Chapter 1

Improving Health Prevention Behavior of Children with Information Systems

Paper I

The economic impact of infectious diseases of children at kindergarten age

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Graichen, J. (2022). The economic impact of infectious diseases of children at kindergarten age. Public Health Forum, 30(3), 201–203. doi: https://doi.org/10.1515/pubhef-2022-0039

Paper II

Improving hand hygiene of young children with a digital intervention: A cluster-randomised controlled field trial

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Paper III

Information Systems Research for the Next Generation: Child-Centricity in a Digital World

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Graichen, J., & Staake, T. (2023). Information Systems Research for the Next Generation: Child-Centricity in a Digital World. Proceedings of the 56th Hawaii International Conference on System Sciences. uri: https://hdl.handle.net/10125/103123

Chapter 2

Investigating Effects of Digital Rewards on Behavior Change of Children

Paper IV

Hand hygiene of kindergarten children - Understanding the effect of live feedback on handwashing behaviour, self-efficacy, and motivation of young children: Protocol for a multi-arm cluster randomized controlled trial

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Paper V

No Longer Without a Reward: Do Digital Rewards Crowd Out Intrinsic Motivation of Young Children?

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Paper VI

The Effect of Digital Rewards on the Motivation of Children to Perform Everyday Health Behavior

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Chapter 3

Promoting Energy Efficiency of Employees with Information Systems

Paper VII

Mitigating Climate Change at Work: Protection Motivation Theory in the Context of Green Information Systems in Organizations

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Appendix

A.1 Publications

Graichen, J., & Staake, T. (2023). Information Systems Research for the Next Generation: Child-Centricity in a Digital World. Proceedings of the 56th Hawaii International Conference on System Sciences. uri: https://hdl.handle.net/10125/103123

Dangis, G., Terho, K., Graichen, J., Günther, S. A., Rosio, R., Salanterä, S., Staake, T., Stingl, C., & Pakarinen, A. (2023). Hand hygiene of kindergarten children-Understanding the effect of live feedback on handwashing behaviour, self-efficacy, and motivation of young children: Protocol for a multi-arm cluster randomized controlled trial. PLOS ONE, 18(1). doi: https://doi.org/10.1371/journal.pone.0280686

Graichen, J. (2022). The economic impact of infectious diseases of children at kindergarten age. Public Health Forum, 30(3), 201–203. doi: https://doi.org/10.1515/pubhef-2022-0039

Graichen, J., Stingl, C., Günther, S. A., Staake, T., Pakarinen, A., Rosio, R., & Salanterä, S. (2022). No Longer Without a Reward: Do Digital Rewards Crowd Out Intrinsic Motivation of Young Children? ICIS 2022 Proceedings. uri: https://aisel.aisnet.org/icis2022/is_health/is_health/8

McKinsey & Company, M., Müller, T., Richter, L., Silberzahn, T., & Padmanabhan, P. (2022). E-Health Monitor 2022 Deutschlands Weg in die digitale Gesundheitsversorgung—Status quo und Perspektiven (1. Auflage). MWV Medizinisch Wissenschaftliche Verlagsgesellschaft. ISBN: 978-3-95466-759-8

Graichen, J., Stingl, C., & Staake, T. (2021). Live-Feedback beim Händewaschen. uni.vers 2021: Mensch und Maschine - Bamberger Beiträge zur Digitalisierung. ISSN: 1618-9019

Graichen, J. (2021). Estimating cost of illness for kindergarten children with contagious diseases in Germany. European Journal of Public Health, 31(Supplement_3). doi: https://doi.org/10.1093/eurpub/ckab164.683

Graichen, J. (2021). Infectious illnesses of young children: Financial burden for rich countries - a literature review. European Journal of Public Health, 31(Supplement_3). doi: https://doi.org/10.1093/eurpub/ckab165.514

A.2 Disclaimer

The following Table 1 presents a comprehensive list of the publication outlets of the published papers and papers under review that are included in this dissertation. In the case of papers with multiple authors, the table also indicates the specific contributions made by myself.

Table 1: Publication outlets of the included papers in the dissertation and personal contributions to each paper.

Paper number	Publication outlet	Own contribution
I	Public Health Forum	[single author]
II	Scientific Reports [under review]	conceptualization, methodology, formal analysis, investigation, project administration, writing - original draft
III	Proceedings of the 56th HICCS	conceptualization, methodology, investigation, project administration, writing - original draft
IV	PLOS ONE	conceptualization, methodology, investigation, project administration, writing - review & editing
V	ICIS 2022 Proceedings	conceptualization, methodology, investigation, project administration, writing - original draft
VI	BISE [under review]	conceptualization, methodology, formal analysis, investigation, project administration, writing - original draft
VII	ECIS 2024 [to be submitted]	conceptualization, methodology, formal analysis, investigation, project administration, writing - original draft

Above table contains the seven papers that are included in this dissertation. It lists the publication outlet or, if under review, the submission outlet. It furthermore specifies own contributions according to the Contributor Roles Taxonomy (CRediT) (Brand et al., 2015).

A.3 German Abstract / Zusammenfassung

In den letzten Jahrzehnten hat sich Technologie als Hoffnungsträger bei der Bewältigung von zwei drängenden Problemen unserer Zeit etabliert: Gesundheit und Klimawandel. Doch trotz technologischer Fortschritte im Bereich Medizin und Nachhaltigkeit nehmen Infektionskrankheiten (Jones et al., 2008) und der Ausstoß von Treibhausgasen (Olivier & Peters, 2020) weiter zu. Neben technologischen und regulatorischen Fortschritten trägt auch das Verhalten eines jeden Einzelnen dazu bei, Infektionskrankheiten und den Ausstoß von Treibhausgasen einzudämmen. Jedoch haben Menschen oft Schwierig-keiten, ihre guten Absichten mit ihrem täglichen Verhalten in Einklang zu bringen. Die Kluft zwischen Absicht und tatsächlichem Verhalten verdeutlicht die Komplexität, Ge-wohnheiten zu ändern und neue Verhaltensweisen anzunehmen. Die Frage, wie Verhaltensänderungen im Kontext von Gesundheit und Klimawandel erreicht werden können, ist somit nicht leicht zu beantworten; sie erfordert vielmehr umfangreiche interdisziplinäre Forschung.

Die Wirtschaftsinformatik kann mit Hilfe digitaler Interventionen Verhaltensänderungen unterstützen und ihre Erforschung vorantreiben. Zudem erlaubt die Einbindung von Messinstrumenten in technische Geräte die Erfassung von Verhaltensdaten in der realen Welt. Diese Daten ermöglichen die empirische Validierung und Erweiterung von Verhaltenstheorien. Trotz dieser Möglichkeiten, sowie der Verfügbarkeit und Skalierbarkeit von digitalen Interventionen, ist die Erforschung von Verhalten in der Disziplin der Wirtschaftsinformatik noch in ihren Anfängen. Die Hauptziele dieser Dissertation bestehen darin, Einblicke in die Wirksamkeit von digitalen Interventionen zur Förderung von gesundem und nachhaltigem Verhalten in der realen Welt zu geben und Verhaltens- und Motivationstheorien empirisch zu validieren. Dies wird durch zwei experimentelle Feldstudien und eine Umfrage-Feldstudie erreicht, die sich auf Verhaltensänderungen von Kindern und Mitarbeitern konzentrieren.

Die ersten beiden Kapitel umfassen die Ergebnisse von zwei Feldexperimenten, welche das Händewaschverhalten von Kindern in Kindertagesstätten untersuchen. Im Rahmen

von Kapitel 1 wird eine digitale Intervention entwickelt und die Anwendbarkeit und Wirksamkeit der Intervention in Kindertagesstätten in Deutschland und in Finnland bestätigt. Die Daten zeigen, dass die Einseifzeit der Kinder beim Händewaschen, ein Indikator für die Qualität der Handhygiene, um 62% verbessert werden kann, solange die digitale Verhaltensintervention aktiv ist. In Kapitel 2 dient die Intervention anschließend als Werkzeug zur empirischen Validierung und Erweiterung von Verhaltenstheorie, insbesondere der Motivation Crowding-Theorie. Die Ergebnisse der Feldstudie liefern empirische Beweise für die Wirksamkeit von digitalen Belohnungen bei Kindern. Dies unterstreicht das Potenzial digitaler Belohnungen und widerlegt mögliche negative Auswirkungen, wie sie von der Motivation Crowding-Theorie vorhergesagt werden. Die Forschung in Kapitel 1 und 2 kann als Leitfaden für Wissenschaftler in der Wirtschaftsinformatik dienen, die Verhalten, insbesondere jenes von Kindern, erforschen. Darüber hinaus bietet sie Praktikern Unterstützung bei der Gestaltung effektiver und skalierbarer Systeme, die speziell auf Kinder ausgelegt sind.

Kapitel 3 beinhaltet die Ergebnisse einer Feldstudie, welche die Motivation von Zugführern untersucht, Grüne Informationssysteme am Arbeitsplatz zu nutzen und dabei zu Energieeinsparungen im Verkehrssektor beizutragen. Die Ergebnisse der hierzu durchgeführten Interviews und Umfragen bestätigen die Anwendbarkeit der Protection Motivation-Theorie im Kontext von Informationssystemen. Die gesammelten Daten zeigen, dass die Motivation der Mitarbeiter, sich an klimaschützendem Verhalten zu beteiligen, von ihrer Wahrnehmung der eigenen Wirksamkeit sowie der Ernsthaftigkeit des Klimawandels abhängt. Die erarbeiteten Motive stellen wichtige Anknüpfungspunkte zur Entwicklung digitaler Verhaltensinterventionen dar, die darauf abzielen, umweltfreundliches Verhalten von Mitarbeitern zu fördern.

Insgesamt zeigt die Arbeit auf, dass mit Hilfe von Informationssystemen Verhaltensänderungen unterstützt und erforscht werden können. Die durchgeführten Feldstudien unterstreichen die Effektivität digitaler Interventionen in realen Umgebungen. Mit dem gewählten interdisziplinären Ansatz und einer Kombination verschiedener Metho-

den werden außerdem bestehende Verhaltenstheorien im Bereich der Informationssysteme genutzt, empirisch validiert und erweitert. Die Ergebnisse der Arbeit legen dar, dass Informationssysteme Individuen bei Verhaltensänderungen unterstützen können und somit das Potential besitzen, die Gesellschaft in ihrer Ambition einer gesünderen und nachhaltigeren Welt zu unterstützen.

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Unpublished Manuscripts

The following pages contain the manuscripts of all papers featured in this dissertation that have not yet been published, namely Paper VI and Paper VII.

The Effect of Digital Rewards on the Motivation of Children to Perform Everyday Health Behavior

Information systems (IS) can serve as a powerful tool for promoting children's learning. In this context, digital, symbolic rewards are frequently employed to enhance task performance. However, it has been observed that once rewards are removed, intrinsic motivation to perform a task may decrease below baseline levels, a phenomenon referred to as motivation crowding. There is a lack of consensus among researchers under which circumstances motivation crowding happens among children. This paper reports findings from a cluster randomized field study that investigates a digital health intervention guiding and rewarding children to engage in everyday health behaviors. Behavioral data from 254 children between the ages of three and six was collected over a five-week period. The results provide empirical evidence that digital rewards successfully helped children adapt everyday health behaviors and refute motivation crowding among children in the context of digital rewards. The findings are important for advancing the use of motivation crowding theory in children, for providing insights into children's behavior, and helping IS researchers develop motivational cues for children. At the same time, the digital intervention outlined in the paper embodies an effective and scalable measure for engaging children in health prevention behavior.

Introduction

During the first decade of life, humans undergo a significant learning process that encompasses a variety of skills (Gesell et al. 1946; Thompson 2001), ranging from basic motoric skills to behavior in social context to establishing health-related habits. As children engage with their surroundings, they repeatedly experience positive or negative reinforcement, which shapes their

behavior patterns (Miltenberger and Crosland 2014). Positive reinforcement is often provided through extrinsic rewards. However, the use of extrinsic rewards may not only have positive effects. While extrinsic rewards initially appear to reinforce the desired behavior, the concept of motivation crowding suggests that the introduction of extrinsic rewards may lead to a decline in intrinsic motivation once the reward is no longer present, ultimately resulting in reduced task performance (Frey and Jegen 2001). While the task was initially enjoyed, the pleasure of engaging in the task is fully attributed to the presence of the reward, rather than the activity itself (Deci 1973).

In the realm of Information Systems (IS), symbolic rewards are a commonly employed tool for promoting behavior change (Evans et al. 2022). The concept of motivation crowding in the context of those digital rewards has been explored within the IS literature for selected use cases (Flüchter and Wortmann 2014; Liu and Feng 2015; Qiao et al. 2017; Wu 2019). However, research in this area has exclusively focused on adults. As IS influence life and learning early in life (Ronimus et al. 2014) and given the distinct ways in which children develop and learn (Kuhn and Pease 2006), it is inevitable to specifically investigate the potential impact of digital rewards on children's motivation. This is especially important because digital rewards nowadays are an integral part of digital learning tools, which are currently experiencing a major upswing in the education space (Nand et al. 2019; Lamrani and Abdelwahed 2020; Fadhli et al. 2020). While digital learning tools are employed in a variety of domains, one promising application of learning IS (if designed properly) is health literacy building (Dunn and Hazzard 2019). IS can support young children in learning everyday health behavior. Since it is unclear how digital rewards affect the motivation of children learning everyday behavior, we ask the following research question:

Do digital rewards for everyday health behavior presented by an IS lead to motivation crowding in young children?

The overall aim of addressing this question is to make a theoretical contribution to the motivation crowding theory for children and to contribute to the future theory-driven design of IS research. To answer the posed research question, we study handwashing behavior because of its relevancy for disease prevention (Luby et al. 2005) and because it is possible to measure the behavior with IS without unintentionally influencing the children. By examining handwashing behavior of children with the help of a field experiment, we can generate theoretical insights that have not yet been explored due to the dominance of laboratory research studying the phenomenon.

While the focus of the field study is to contribute to theoretical knowledge, the investigation of the use case itself is also valuable. Studying health prevention behavior of children and hand hygiene in specific ways to improve it is highly relevant, given the gravity of infectious diseases of children on their development, family dynamics and broader society ("author citation"). When sick, not only children have to stay at home, but caregivers often must take leave from their jobs as well. Many times, the caregiving responsibility is shouldered by women, exacerbating existing gender-based inequalities in the workforce. To mitigate this hardship, it is imperative to implement both childcare concepts for sick children and preventive health solutions. The establishment of a good handwashing routine or healthy behavior in general during early childhood holds significant advantages, given that the health practices learned during young years tend to be sustained throughout one's lifespan (Forrest and Riley 2004; Center on the Developing Child 2010).

We developed a digital health IS for young children that uses digital rewards to promote good hand hygiene among children to investigate and influence handwashing behavior. We tested

the intervention in a real-world setting and demonstrated its practical relevance in a field study. This way we examined how the digital reward provided by our solution affects children's hand washing performance.

The research presented in this paper is structured as follows: In the next section, we define motivation crowding, provide an overview on the concept of motivation in IS and child research and develop hypotheses regarding our research question. Afterwards, we propose an IS to improve handwashing behavior of children in day care centers by introducing the experimental design of our pre-registered cluster randomized controlled field study to evaluate the efficacy of the artifact in practice. We then elaborate on the implications of the result in light of motivation crowding theory and our hypotheses. Finally, we discuss implications, limitations, and future research avenues before concluding with a summary of our results.

Theoretical Background and Hypotheses Development

The concept of intrinsically motivated tasks refers to activities that individuals perform purely for their inherent interest or enjoyment in the task itself (Deci 1973). Motivation crowding theory pertains to the impact of extrinsic rewards on intrinsic motivation. The theory posits that extrinsic rewards can undermine initial intrinsic motivation and subsequently lead to adverse impact on the rewarded behavior once the reward is no longer present. Researchers have shown long-standing interest in the reinforcing effect of extrinsic rewards on behavior, with the earliest descriptions of unintended consequences appearing in literature in the 1970s (Titmuss 1970; Deci 1971). While economists and psychologists have been actively engaged in discussions about motivation crowding and its impact since early on (Deci et al. 2001; Festré and Garrouste 2015), it is also a research topic in other disciplines nowadays, such as IS research, as the following paragraphs depict.

The Concept of Motivation in Information System Research

IS research involves the investigation of various human-system interactions and thus, motivation is a relevant topic in the field (Wu 2019). The concept of intrinsic and extrinsic motivation has been investigated in several application fields in IS literature, e.g., in gamification (Liu et al. 2017), social Q&A communities (Zhao et al. 2016), and open-source software development (von Krogh et al. 2012). Since IS enable the deployment of salient and timely rewards, not only motivation but also motivation crowding is a relevant phenomenon in IS research. The exploration of motivation crowding in IS research is currently limited to specific domains. For example, motivation crowding has been investigated in the context of online product reviews (Wu 2019), user-generated content platforms (Liu and Feng 2015), different pro-social behaviors rewarded with monetary incentives (Qiao et al. 2017), and feedback to promote sustainable travel behavior (Flüchter and Wortmann 2014). Motivation crowding in the context of IS and children has received no attention, despite the large potential of IS for child education. With their technical possibilities, IS can guide children while performing an action without the presence of a teacher and are therefore a good tool for learning everyday tasks. Furthermore, IS are highly scalable, and real-time data processing enables IS to play out performance-contingent rewards to children during or right after an action. However, it is unclear how those unique features of digital rewards affect motivation of children, i.e., how potential motivation crowding effects appear in the context of digital rewards.

IS provide a valuable opportunity to investigate motivation crowding effects in real-world settings, as they enable the collection of extensive data. In particular, IS serve as effective research tools for studying behavior, as they allow for the measurement of long-term effects in field experiments, which can complement findings from laboratory experiments and

observational studies (Goes 2013). Therefore, conducting research using IS holds the potential to generate novel insights into motivation crowding through field studies.

Motivation Crowding and its Role in Child Learning

In the learning journey of children, children experience constant reinforcement from their environment, which influences their behavior (Miltenberger and Crosland 2014). Extrinsic rewards are a frequently used means for positive reinforcement. However, while extrinsic rewards might reinforce the incentivized behavior when the reward is given, they can also lead to a reduction of the child's intrinsic motivation to perform a task when the reward is no longer present (Deci et al. 1999).

Motivation crowding is a concept discussed in psychology and behavioral economics literature, referring to situations where activities initially driven by intrinsic motivation are then externally rewarded (Promberger and Marteau 2013). When extrinsic rewards are introduced for tasks that are inherently enjoyable, individuals may attribute their motivation to the external reward rather than their intrinsic drive. Consequently, when the reward is removed, the motivation to perform the task can decrease below the baseline level (Lepper et al. 1973). This decline in motivation appears to be more pronounced when rewards are highly salient and immediately available (Ross 1975; Sarafino 1984). Studies have found similar effects for performance-contingent rewards, where rewards are given only upon successful completion of the task. However, task-contingent rewards, provided regardless of performance, and unexpected rewards have shown no significant influence on children's intrinsic motivation to engage in the task (Greene and Lepper 1974; Boggiano et al. 1985).

Since nearly all studies on children and motivation crowding effects are conducted in laboratory settings (Deci et al. 1999; Esteves-Sorenson and Broce 2020), not only the timespan of observations but also the investigated activities are limited to those that are sufficiently

observable in the laboratories. Research on motivation crowding among children due to tangible (material and symbolic) rewards is mostly conducted in the context of playful activities, e.g., mazes, building blocks, drawing (Deci et al. 1999; Esteves-Sorenson and Broce 2020). Studies that build on motivation crowding at the interface of children and health are rare. Two studies exist that examine the effect of rewards on healthy eating behavior (Cooke et al. 2011; Loewenstein et al. 2016). While both studies were conducted in the field, the transferability of their findings is limited. Children get used to new tastes, which influences subsequent eating behavior, making it difficult to measure motivation crowding. Also, the fact that observers were present during mealtimes might have influenced children's behavior. Furthermore, as many children do not like to eat vegetables to begin with, their initial intrinsic motivation is low.

For many other use cases, this looks different. Young children, in general, are eager to learn, curious by nature and like play-based learning (Keung and Cheung 2019). Unlike adults who are often confined to the distinction between social and monetary markets (Heyman and Ariely 2004), young children are not yet trapped in such dichotomies (Strauss 1952). Consequently, many activities have the potential to trigger motivation crowding when working with children. In our study, we specifically investigate motivation crowding in the context of handwashing. Handwashing, if performed without obligation in a playful setting, is a task that is typically enjoyable for children due to its interactive nature involving water and soap. However, the introduction of extrinsic rewards may undermine the intrinsic enjoyment associated with handwashing. Examining motivation crowding in the context of handwashing is not only theoretically interesting but also holds practical relevance, as it is an essential health activity for individuals of all ages and plays a crucial role in preventing the spread of diseases (Lau et al. 2012).

To conclude, though many publications around children's motivation crowding exist, it is unclear how digital rewards for health-related behavior impact the motivation of children. Gaining more knowledge about contexts that promote motivation crowding is important if the potential of digital rewards is to be fully exploited to support children in learning everyday health behavior.

Hypotheses regarding the Effect of Digital Rewards on Children's Motivation

Drawing on the described related literature on motivation crowding, we posit the subsequent hypotheses for a digital health intervention that either only instructs or instructs and rewards children. Generally, rewarding reinforces behavior by increasing extrinsic motivation. This leads us to our first hypothesis.

H1: The presence of digital rewards has a positive impact on the task performance of children regarding the rewarded activity.

We believe that the removal of the external reward undermines intrinsic motivation and thus task performance. While the activity was previously performed by children because of norms and out of curiosity, according to theory, they now want to be rewarded for it and are primarily extrinsically motivated. Thus, motivation crowding happens as soon as the reward is withdrawn, lowering task performance. We expect this outcome in two cases: when the reward is expected (due to the presence of the system that formerly provided rewards, now only providing instructions) and when the system is completely absent.

H2: Withdrawing the digital reward sharply decreases task performance, even below the baseline level.

While the first two hypotheses refer to the case in which rewards are provided, we expect different outcomes for the sole provision of instructions, captured in hypothesis three and four. While the instructions are in place, we anticipate an increase in intrinsic motivation and thus task performance.

H3: A digital intervention without rewards (only instructions) will still have a positive impact on task performance, although this impact will be smaller compared to the intervention with rewards.

The hypothesis is based on theory suggesting that engaging children in captivating and appropriately challenging learning activities can enhance their intrinsic motivation (Deci et al. 1981; Cordova and Lepper 1996), as opposed to relying on external rewards. We anticipate that the provision of instructions will not only increase intrinsic motivation while the instructions are in place, but also hypothesize that the motivation and task performance will be (partially) sustained even after the instructions are withdrawn. We thus assume that no motivation crowding occurs when the digital instructions are withdrawn (in contrast to withdrawing the reward, see H2).

H4: Withdrawing the digital intervention without rewards will lead to a slight decrease in task performance, but this decrease will not fall below the baseline level.

Confirming or refuting our set of hypotheses will provide an extensive picture on child behavior in the context of digital rewards, which is relevant for the design of motivational cues in the IS discipline as well as for the understanding of young children's behavior in general. In the following, we describe our research methodology to analyze the posed hypotheses.

Research Methodology

We investigated our hypotheses with the help of a digital intervention in a field study to address the identified research gap pertaining to the impact of digital rewards on the motivation of children to learn health behavior. Comprehensive information concerning the design of the field experiment can be found in the trial protocol article ("author citation"). The study protocol was approved by the ethics committee at the authors institutions in Finland and Germany.

Design of the Digital System and the Intervention

We developed a digital system to improve handwashing, an everyday health prevention behavior, among children in day care centers. The system was installed in the washing facilities of the day care centers and consists of a touchless faucet, touchless soap dispenser, and a feedback display (see Figure 1). All devices sent and received information via Bluetooth to a gateway which relays the data to a cloud infrastructure, where data was processed and visualized.

Figure 1: Example of experimental setup at a washbasin

The centerpiece of the system is the feedback display, which shows the intervention, an animation with handwashing instructions, and a reward in the form of an animal animation if the child performs the task adequately (usage of soap and water for a defined timespan). The animated handwashing instructions include all relevant handwashing steps (European Centre

for Disease Prevention and Control 2020), including the wetting of hands and the various soaping movements (for selected animation screens see Figure 2). The design of the instruction and reward screens is based on previous studies of health games for children (Ingadottir et al. 2022), and was confirmed through pre-tests with individual day care center children of different ages who provided feedback on the design. Furthermore, we pre-tested the digital system and the corresponding intervention to test if it is adequate to help us answer our research question. Results from the pre-study indicated that our intervention was successful in increasing handwashing quality.

Figure 2: Selected screens of the intervention animation

Data Collection and Outcome Measures

In the first quarter of 2022, we contacted three eligible day care centers and all of them agreed to participate in our field study. To prevent diffusion of the intervention, strict separation was enforced between the control and the two treatment groups by randomly assigning entire day care centers to one group or the other with a computer program. The split in the reward group into two subgroups in the post-phase was implemented on two different floors and building parts of the respective day care center. We installed our digital system at 35 washbasins across the three day care centers in Finland and collected data on handwashing observations, including the timing of the water and soap extraction, over at least 23 weekdays in each day care center in May and June 2022.

Our cluster randomized controlled study aimed at investigating the effect of motivation crowding on children's motivation to wash hands. As in existing literature, e.g., Lepper et al. (1973) and (Deci et al. 2001), we measure the time spent performing an activity as a proxy for motivation. Our study hardware provides objective and measurement data on time spent soaping the hands. To complement the measurement data, independent research assistants from Finland (not further involved in the experiment or in the analysis of the sensor data) conducted observations and interviews with children and teachers, as well as a survey with parents, to assess aspects that could not be directly measured, such as changes in attitudes. The first round of interviews and observations occurred at the end of the baseline phase, before the intervention started, to establish a baseline for children's capabilities and views on handwashing. Towards the end of the intervention phase, we conducted a second round of interviews and observations to investigate changes in children's attitudes and behavior. In addition, staff interviews and parent surveys were conducted. At the end of the post-phase, the final round of interviews and observations with children was conducted.

Experimental Procedure

A five-week cluster randomized controlled trial was conducted in three day care centers in Finland with children aged three to six years. The study hardware (smart faucets, soap dispensers, and gateways) was installed at the washbasins of all study groups. The day care centers were randomly assigned to one of three study groups (control, instruction, and reward group), and handwashing behavior was measured in the baseline, intervention, and post-phase (see Figure 3).

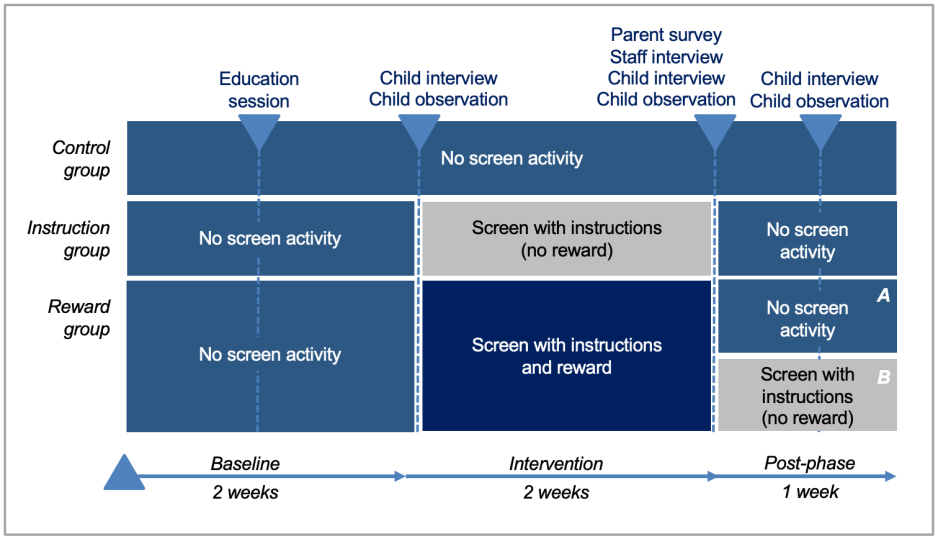


Figure 3: Experimental design of the cluster randomized field study

Handwashing performance of children was measured in a baseline phase across all four study groups without the presence of any intervention. To ensure uniform basic knowledge on hand hygiene, a short educational video was shown to the children in the classroom once in each day care center halfway through the baseline phase. Following the baseline phase, displays were installed above washbasins in all groups except for the control group to deliver the respective treatments. In the intervention phase, the instruction and reward group received animated handwashing instructions, with the reward group receiving a performance-contingent reward following the instructions. The instruction group received only instructions without any reward. The control group did not receive any visible intervention during the intervention phase. After the intervention phase, tablets were deinstalled, except for part B of the reward group, and measuring devices remained in all day care centers for the post-phase. During the post-phase, the control, the instruction, and part A of the reward group did not receive any further input from the tablets, while part B of the reward group continued to receive instructions without any reward.

Research Results

Our study involved 254 children in total, with our system recording handwashing activities of 177 children on average across all day care centers. Throughout the experiment's three phases, the equipment recorded 5,709 handwashing procedures (water and accompanying soap extraction), which are processed in the result analysis. This number includes all recorded handwashing procedures except those, that were outside of the day care center opening hours (e.g., for cleaning purposes). For this study, handwashing processes are defined as soap extractions followed by water extractions. Furthermore, we observed 279 handwashing procedures of the children in the day care centers at 3 different points of time. We conducted 116 interviews with 61 children across the three experimental phases. We conducted eight staff interviews and collected 53 surveys from parents. This gave us valuable insights into the system's acceptance and perception among young children.

In Table 1, we present descriptive characteristics for the full sample as well as for each experimental group. The table provides the number of handwashes per cluster as well as cluster mean and standard deviation for the number of children in day care center per day across all experimental phases. Furthermore, the table reports the mean soaping time in the baseline phase. Across all clusters, the mean soaping time during the baseline phase was 5.99 seconds. Our result analysis adheres to the CONSORT guideline for randomized trials (CONSORT Group et al. 2010; Campbell et al. 2012), and thus, we do not provide further details on tests of baseline differences (Altman 1985; Moher et al. 2010; Senn 2013; De Boer et al. 2015).

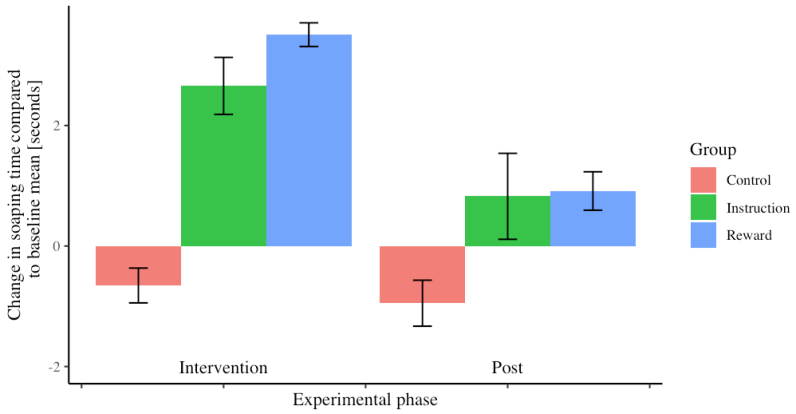
Table 1 | Descriptive Statistics Measurement Data

	Full sample	Control group	Instruction group	Reward group
Mean number of children in day care center per day (all experimental phases)	63 (18.24)	56 (6.53)	51 (7.55)	70 (21.37)
Number of handwashing processes (all experimental phases)	5,709	1,741	524	3,444
Mean soaping time in baseline phase	5.99 (6.39)	6.59 (6.52)	5.38 (5.63)	5.61 (6.36)

Descriptive statistics for the full sample and the different clusters. Standard deviations are reported in parentheses.

Effect of the Intervention on Handwashing Motivation

The effect of our intervention on the soaping time are visualized in Figure 4, which visualizes changes in mean soaping time per experimental group. Soaping time for both the instruction and reward group rises during the intervention phase and remains slightly higher than the baseline level in the post-phase. The average increase in soaping time in the reward group is 62.54% during the intervention phase and 18.99% during the post-phase, both compared to the baseline phase. For the instruction group, the increase lies at 49.40% and 0.01%, respectively.



Note: Bars indicate the mean difference in soaping time per experimental group compared with the mean of the baseline phase. Error bars represent mean ± SEM.

Figure 4: Change in mean soaping time across experimental phases

To formally estimate the effect sizes, we model the following relationship using ordinary least squares:

$$y_{it} = a_i + IN_{it}^{intervention} \cdot \left(\beta_1 + \beta_2 T_i^{instruction} + \beta_3 T_i^{reward}\right) + IN_{it}^{post} \cdot \left(\beta_4 + \beta_5 T_i^{instruction} + \beta_6 T_i^{reward}\right) + \varepsilon_{it}$$

where the dependent variable y_{it} represents the soaping time in day care centre *i* on timestamp *t*. We include an individual fixed effects coefficient α_i for each day care centre to control for fixed differences in the washing places across the different day care centres. The variable $IN_{it}^{intervention}$ is 0 during the baseline and the post-phase, and 1 in the intervention phase. By contrast, the variable IN_{it}^{post} is 0 during the baseline and the intervention phase, and 1 in the post-phase. $T_i^{instruction}$ is a treatment group indicator that takes the value of 1 if a day care centre belongs to the instruction group and is else 0. Likewise, T_i^{reward} is a treatment group indicator that takes the value of 1 if a day care centre belongs to the reward group and is 0 otherwise. The standard errors are clustered on the day care centre level. The error term ε_{it} captures all effects that are not considered in our model.

The effect of the instruction and the reward on the handwashing behavior (measured by soaping time) across the three experimental phases is captured in Table 2 and further elaborated in the following. We see a small but statistically significant ($p = 0.034$) negative effect of the intervention phase on soaping time. In our field study, the hardware was installed well in advance of data collection, allowing the children to become accustomed to the new faucets. Nevertheless, we see a Hawthorne effect, as teachers and children may have been more aware of being part of a study in the beginning of the experiment. We see a positive effect of the instructions and the rewards on the soaping time in the intervention phase (both statistically significant at the 0.1% level). The positive effect is larger for the reward group, where we also see a positive effect in the post-phase ($p = 0.020$). We also tested if subgroup A and B of the reward group differed in the post-phase by including an additional binary variable (1 for instructions in the post-phase, else 0). We find no statistically significant different outcome in the post-phase of the two subgroups. Furthermore, we evaluated possible changes in handwashing frequency. We do not see any statistically significant effects of our intervention on the handwashing frequency in the day care centers ($F = 0.560$, $p = 454$).

Table 2 | Main Experimental Outcomes

		Handwashing behavior	
Phase effect	*Intervention phase*	-0.69* (p=0.034)	(0.33)
	Post-phase	-0.94 (p=0.147)	(0.65)
Instruction effect	*Intervention phase*	3.17*** ($p=0.080 \times 10^{-3}$)	(0.80)
	Post-phase	1.65 (p=0.112)	(1.04)
Reward effect	*Intervention phase*	4.12*** ($p=0.074 \times 10^{-8}$)	(0.67)
	Post-phase	1.68* (p=0.020)	(0.72)
Overall intercept		5.98	
Observations		5,709	
R^2		0.03	

The table displays the effects on soaping time in seconds. Standard errors are reported in parentheses, adjusted for clustering at the day care center level. *, **, and *** indicate significance at the 5%, 1% and 0.1% level, respectively.

Our measurement results get backed up with data from visual observations. During observations in the day care center, the observing researchers rated the handwashing performance, defined as the sum of correctly completed handwashing steps divided by the total number of handwashing steps. In the baseline phase there was no statistically significant difference in handwashing performance of the children between the groups ($p = 0.063$). In the intervention phase however, the handwashing performance of children in the reward and the instruction group was statistically significantly better than in the control group ($p < 0.001$). With the

observation, we were able to rule out certain pitfalls of our digital measurements: children with the digital intervention were performing the soaping movements while standing in front of the screen (rather than solely watching the animation instead of soaping hands).

With data from our interviews and surveys we were able to get further qualitative insights regarding our intervention. During the structured open-ended children interview, children got the chance to talk about their handwashing abilities, their motivation to wash hands, and their view on the intervention. Children were positive about the new handwashing set-up, thus, confirming the engaging, child-friendly design of our intervention. The interviews with the day care staff after the intervention phase helped us to evaluate the practicability of the digital intervention. The staff confirmed that the intervention supports everyday day care center routines and precluded unwanted effects (e.g., certain children washing their hands all day to see the animation). In the parent survey, it was found that 50% of the parents acknowledged a significant improvement in their children's handwashing skills in both the reward and instruction group throughout the duration of the experiment. The remaining 50% either reported no change in performance, observed a decline in performance, or did not provide a response to the question.

Discussion

Implications for Theory and Practice

The aim of our study was to investigate if task performance for a specific activity decreases due to motivation crowding in children as a response to digital rewards. In a field study we investigated task performance over the course of five weeks in a natural environment that is not artificially induced, as children continued their regular handwashing routine in their day care center.

From a theoretical standpoint, there are various implications. First, our study proves the strong effects of digital rewards on performance while the rewards are in place. In line with our first hypothesis (H1), the provision of a digital reward resulted in a significant increase in task performance for handwashing, with the effect being present right from the onset of the intervention phase. This can be attributed to the reward that serves as additional performance feedback (Ryan et al. 1983), thereby increasing the children's motivation. Second, the findings of the post-phase provide no empirical evidence for a change in task performance that could be attributed to motivation crowding effects of digital rewards on motivation of young children. During the post-phase, we observed that the removal of rewards in the reward group resulted in a drop in handwashing task performance (for subgroup A and B). However, the performance did not drop below the baseline level for either subgroup, soaping time stayed significantly longer than compared to the baseline phase (contrary to our hypothesis H2). Thus, we do not find empirical evidence for motivation crowding effects. The two subgroups in the reward group allowed us to examine whether the adverse effects were specifically linked to children's expectations of receiving rewards. In subgroup A tablets were deinstalled before the post-phase and thus, children might have no longer expected any rewards. In subgroup B in contrast, tablets were still installed in the post-phase and showed instructions and thus, rewards were expected by the children. Since we found no statistically significant differences between the two groups, we provide empirical evidence to refute motivation crowding effects of digital rewards, whether expected or not.

While the instructions alone (no reward), also had a positive impact on handwashing task performance (in line with hypothesis H3), its effect were smaller than that of the reward-based intervention, suggesting that digital rewards provide stronger feedback than mere display instructions. In the post-phase, the instructions group experienced a decline in performance but maintained a level of performance above the baseline level (in line with hypothesis H4),

indicating that prior learning contributed to continued handwashing behavior. The performance level of the display-only group was lower than that of the reward-based interventions during both the intervention and post-phases, underlining the overall positive effect of the reward.

To conclude the theoretical perspective, our findings enhance the understanding of motivation crowding theory in the context of young children and digital rewards provided by IS. By conducting measurements in the field, we were able to demonstrate that digital rewards do not lead to decreased task performance, as soon as the rewards are withdrawn, a phenomenon that motivation crowding theory would predict. While there might have been a slight decrease in motivation due to the reward, this drop might be overtaking by learning effects. We provide empirical evidence that digital rewards positively contribute to task performance regarding health prevention behavior in children and thus, do not lead to motivation crowding effects. This finding challenges the potential negative impact of digital rewards on children's motivation and contributes to the advancement of understanding children's behavior and the design of motivational cues in IS research targeted towards children.

From a practical standpoint, our study holds implications for the design of IS aiming at improving children's everyday health behavior. Our field study demonstrates how IS can be used to encourage health prevention behavior and provides practical implications for the design and implementation of future IS interventions aimed at promoting children's health behavior. Our intervention showcases how educational institutions, such as day care centers and schools, can utilize IS to progress towards their vision of a digitally supported care offering. Our intervention provides a practical possibility for improving hand hygiene in day care centers, a pressing issue in practice. Despite handwashing being performed regularly by children, their behavior before our intervention still fell short of good hand hygiene standards, underlining the relevance of our system.

Limitations and Future Research

While our study provides valuable insights into motivation crowding theory, it is important to note several limitations and areas for future research. Despite using the longest timespan of continuous day care days without vacations, our field experiment still falls short of evaluating the formation of a new habit, for which a longer duration of data collection is needed. We tracked the number of children in each day care center on a day-to-day basis to ensure that no systematic attrition occurred in a day care center but are not able to rule out random attrition. Furthermore, we were not able to allocate handwashing data that was collected by the system to individual children and insights from their interviews to protect the children's personal privacy. In general, when doing behavioral experiments and designing IS interventions like ours, backdrops of technology, like data privacy risks should always be kept in mind (Sunyaev et al. 2015), especially since children are particularly vulnerable, protecting their privacy in digital health solutions is essential. Despite these limitations, our study underscores the potential of IS to promote positive behaviors and improve public health outcomes among children.

While in our setting, for the day care centers under study, we do not find evidence for motivation crowding, it still might show up in other settings and thus, should be subject of investigation of additional field studies. Future research should furthermore explore the effects of digital rewards on other behaviors besides handwashing, such as physical activity, healthy eating, or screen time. While our study focused on children aged three to six years, it remains unclear whether the effects of the IS would be similar for older children. Replicating our study with a larger and diverse sample of children could offer a more comprehensive understanding of the generalizability of the effects of digital rewards across different populations.

Conclusion

The presented study introduced an IS designed for children to promote good hand hygiene. It was tested in the field to explore the effectiveness of digital rewards in enhancing the motivation of children in day care centers to engage in everyday health behavior. The results provide empirical evidence that digital rewards are highly successful in encouraging health behavior. In our field study, the task performance of the reward group increased by 62.45% while the rewards were in place. The findings refute the notion of decreased task performance upon reward withdrawal, as predicted by motivation crowding theory. Instead, the task performance in the reward group remained 18.99% above the baseline level even after the rewards were withdrawn. The effects of the rewards on task performance were evident immediately upon their introduction and removal. To conclude, the use of IS with rewards as incentives for positive behaviors holds great promise in improving public health outcomes in children. Nevertheless, the study also emphasizes the need for further research to investigate the long-term effects of digital rewards on motivation and habit formation in children across different age groups and settings. The study highlights the critical importance of establishing healthy behaviors during early childhood and underscores the significant potential of IS in promoting healthy practices throughout an individual's lifespan.

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Mitigating Climate Change at Work: Protection Motivation Theory in the Context of Green Information Systems in Organizations

Introduction

Climate change and its consequences have attracted significant public attention and have been identified as one of the foremost challenges of our era (United Nations 2021). Despite this awareness, global greenhouse gas emissions continue to rise (Olivier and Peters 2020). Reversing this trend necessitates collective efforts, including policy and technological advancements, as well as individual actions (Gifford et al. 2011; Liverani 2009). Individuals in private households and organizations alike must reassess their behaviors. Most organizations have realized that environmental sustainability is crucial for their own existence (Starik and Marcus 2000) and acknowledge the role that employee's behavior plays in their growing environmental sustainability efforts (Norton et al. 2015). However, they are often struggling to make employee behavior more sustainable (Unsworth et al. 2021), as routines and habits are not easily altered.

In our research, we investigate how Information Systems (IS) can support sustainable employee behavior. Research in Green IS shows that IS cannot only help make decisions more sustainable through automation, but also through nudging and sensemaking (Degirmenci and Recker 2023). Sensemaking is a process of re-inspection, re-evaluation, and re-orientation that organizations undergo as part of a sustainability transformation (Thomas et al. 1993). Research has shown that IS can play a crucial role in supporting this environmental sensemaking process and established design principles for sensemaking technology (Seidel et al. 2018). While sensemaking can occur

at various levels, including the organizational, and the team level, it ultimately starts with the individual employee (Degirmenci and Recker 2023). This paper focuses on the individual level, as employee behavior plays a critical role in sustainability efforts within organizations, while not being easily altered. Changing routine behavior and habits is challenging as habitual behaviors help humans cope with their limited information processing abilities and other bounds to rationality (Thorgeirsson and Kawachi 2013). Transforming habitual behaviors thus requires, next to the right attitude, high commitment, effort and time (Maio et al. 2007).

In recent years, researchers have shown the potential of IS as an effective tool to change behavior of individuals in the private space, e.g., with digital feedback interventions (Tiefenbeck et al. 2018). In the organizational context, sustainability transformations also start with individuals, but individuals in organizations function differently than individuals in private life (Kotsopoulos, Bardaki, et al. 2017). In contrast to energy conservation efforts at home, which are associated with monetary savings for the individual household, employees often do not have direct incentives to save energy at work. Therefore, it is important to better understand workers and their motives to act environmentally responsible. Thus, we ask the following research questions: What are motivational affordances of employees to act pro-environmentally friendly in their daily routines at work? How are those affordances connected to employee's perception of Green IS at work? And what affordances hold people back to pursue pro-environmental behaviors at work?

Theorizing on motivational affordances ultimately helps to design IS that are tailored to employees' motives, enabling effective behavior change (Howard et al. 2010). We use Protection Motivation Theory (PMT) to elaborate on motivational affordances of employees to act environmentally sustainable and connect it to the perception of existing Green IS in the organization under study. While employee's behavior has an inevitable impact on green

performance of organizations across industries (e.g., with company cars and office heating), we study employees' motives in a context where the environmental impact of daily routine behavior is particularly large, namely train driving. In transportation research, developing Green IS can be especially useful, as the field is currently dominated by qualitative interventions that are not scalable (Huang et al. 2018). Telematic systems, GPS and other sensor-based data that already exists in trains enable real-time processing of the energy consumption of trains and the ability to provide digital real-time feedback interventions to train drivers in the driving cabin. Developing interventions that are scalable, and integrable into existing systems can be of high value, if they tackle motivational affordances of employees.

The paper is structured in the following way. First, we review literature on IS in connection with environmental sustainability and provide the contextual background of our research, energy efficiency of transportation staff. Subsequently, we introduce PMT and related studies. Utilizing PMT as a foundation, we introduce our research model and associated hypotheses. Next, we detail our methodology, followed by the presentation of the analysis results. Finally, we explore the theoretical and practical implications, limitations, and conclusions of our research.

Related Work & Hypotheses Development

Environmentally Sustainable Behavior Change and Information Systems

In recent decades, there has been a growing interest in environmental sustainability within the field of IS research (Dedrick 2010). Initially, research in this area was primarily focused on Green Information Technology, specifically addressing the development of resource-efficient technical equipment and energy-efficient operation of it (Watson et al. 2008). However, the concept of Green IS has broadened this focus and seeks to explore the ways in which IS can be harnessed to

promote sustainability in the overall economy (Watson et al. 2008). Numerous IS researchers have called for increased research efforts towards the development of Green IS (Melville 2010; Seidel et al. 2013; Zhang et al. 2011). To understand the human factors that influence sustainable technology adoption and use, an interdisciplinary approach that draws from multiple fields of study is essential for advancing the development of Green IS. Next to the exploration of Green IS in the context of design science, behavioral science is a promising research avenue to advance Green IS research (vom Brocke et al. 2013).

Green IS literature has started exploring strategies for promoting sustainable behaviors among individuals (Dedrick 2010; Watson et al. 2010). The potential of IS to alter behavior is high: IS can serve as a means to apply behavior change theories at scale and at low cost (Loock et al. 2013). This potential is far from being explored, further research is needed to gain deeper insights into the design of effective IS artifacts that can promote sustainable behavior (Gholami et al. 2016; Loock et al. 2013; Melville 2010; Watson et al. 2010). In the private space the field is more researched than in organizations (Kotsopoulos, Bardaki, et al. 2017). For example, research on energy-efficient behavior of individuals in the residential sector is widespread (Wilson and Dowlatabadi 2007). To be able to transfer findings from the residential sector to the commercial one, much more field data on the behavior of individuals within organizations has to be collected (Cibinskiene et al. 2020; Payne 2006).

There appears to be a limited understanding of the decision-making mechanisms that employees use to engage in pro-environmental behavior at work, despite the recognized impact of their actions on the organization's carbon footprint (Cibinskiene et al. 2020; Dixon et al. 2015; Schall and Mohnen 2017). Organizational settings pose a particular challenge in promoting energy efficiency among employees, as there are usually no direct financial incentives for individuals and

information on individual energy usage is hardly available (Carrico and Riemer 2011). In sustainability transformations in organizations, Green IS can support the key process of sensemaking on various levels of the organization (Butler 2011; Seidel et al. 2013). Sensemaking claims that routinized behavior of employees can be changed with questioning and reflection (Degirmenci and Recker 2023). One study examining the sustainability transformation in an organization and the underlying sensemaking processes on an individual level is a study by Degirmenci et al. (2023). The study investigates the role of reflective disclosure and information democratization on employee printing behavior. While printing is a widespread routine behavior, it is important to examine other areas of employee behavior to determine the extent to which the findings can be generalized and to address actions that have a more significant environmental impact.

In the past, the most widely adopted strategy for promoting energy-efficient behavior was the provision of information (Staats et al. 2004). However, this strategy only has a marginal effect (Cialdini et al. 1991) as promoting energy efficient behavior at work often means changing habitual and routinized behavior of employees. Habitual behavior is hard to change and can only be successful if individuals are motivated to pursue the envisioned behavior (Kotsopoulos, Thanasis, et al. 2017). In IS research, literature investigating the motivation of individuals exists in different domains: crowdsourcing (Kaufmann et al. 2011; Leimeister et al. 2009; Zhao and Zhu 2012), E-Commerce (Wright 2010), engagement in online communities (Federspiel et al. 2014), development of apps for social software platforms (Hilkert et al. 2010), and fitness apps (Rockmann and Maier 2019). However, IS research on motivational affordances for environmentally sustainable behavior of employees and the use of green IS at work is limited. An established theory that investigates motivation in the context of habitual behavior is the PMT. The

theory originates from the health sector but can be applied to the corporate sustainability context, as we will discuss further after elaborating on our research context.

Research Context: Changing Driving Behavior in the Organizational Context

In the life of an adult, 26% of personal emitted greenhouse gases come from transportation (Federal Statistical Office of Germany 2020). Several studies exist that examine how individual transportation decisions in private life can be influenced towards energy efficiency, e.g. by examining how to encourage public transportation choices (Marek et al. 2018; Tørnblad et al. 2014) and reduce private vehicle use (Kormos et al. 2015). Also in the field of IS, research exists on how to alter transport behavior of individuals, e.g., with IS enabled feedback (Flüchter and Wortmann 2014; Rolim et al. 2017).

Research on energy efficiency behavior in the commercial transportation context on the other hand is limited (Dixon et al. 2015; Gosnell et al. 2016), despite its potential to not only reduce the carbon footprint but also lower costs for companies (Gosnell et al. 2016). While studies exist that show how energy-efficient driving can be enforced with system changes in the commercial context (Xu et al. 2017, p. 20), the transportation staff, which has a high stake in reducing emissions, is an often overlooked factor in research and practice (Huang et al. 2018). Improving the driving behavior of transportation staff is a cost-effective approach to reduce CO2 emissions within a short period of time and without high investments, e.g. the purchase of new vehicles (Schall and Mohnen 2017). However, conventional training to promote energy-efficient driving and conventional in-vehicle feedback devices show only short-term effects on energy consumption that quickly disappear (Huang et al. 2018). Evidence from small-scale field studies suggests that digital feedback interventions may be more successful in promoting long-term pro-environmental behavior in the commercial transportation context (Dahlinger et al. 2018). Long-term behavior change in driving

of employees is challenging due to the repetitive nature of driving and its highly habitual and automated features and requires an extension of existing motivational models (Gardner 2009). While individuals in private life have the incentive to save costs with energy-efficient driving, this incentive slips in the organizational context, where savings go directly to the employer and might even be overtaken by other performance metrics. It is therefore promising to understand motivational affordances of employees to engage in energy-efficient driving behavior. If IS enabled feedback and other digital interventions in the commercial transportation sector are to be employed successfully, they need to be designed in line with motivational affordances of the transportation staff.

One part of the emissions in the transportation sector can be back traced to train travels. Thus, efforts are needed to make train operations more efficient. The energy efficiency of trains is influenced to a large extent by their drivers (Deutsche Bahn AG 2018), which have a direct impact on their companies' energy consumption and thus also financial performance through their driving behavior. Practitioner data indicates that drivers adhering to best practices use 30% less energy than less qualified drivers without compromises on safety and punctuality. Thus, train driving is an impactful use case to be researched.

Protection Motivation Theory

PMT was first introduced by Roger (1975) to provide an understanding of the factors that influence risk adaptive behavior in individuals. Initially, the theory was designed to explain changes in health-related behaviors in response to perceived risks (Rogers 2003, 1975). However, PMT has the potential to be applied in a wide range of contexts (Maddux et al. 1982; Westcott et al. 2017). According to the theory, individuals weigh the risks and benefits associated with any decision, often subconsciously (Rogers 2003, 1975). The level of perceived threat and coping mechanisms

results in their behavior. Within the cognitive process of threat appraisal, individuals evaluate if a specific risk is threatening. Three main elements determine the level of threat appraisal: the perceived vulnerability and severity to the specific thread, and the rewards associated with current (non-risk protective) actions. The second cognitive process, following the appraisal of the threat, is the coping appraisal and investigates if own actions are perceived to effectively help manage the threat. Coping appraisal is composed of three main elements. Self-efficacy relates to the ability that individuals grant themselves to take coping actions while response efficacy relates to the efficacy of protective actions. The third element, costs, are perceived monetary and non-monetary costs that arise as a result of the protective actions. Both cognitive processes, threat and coping appraisal, are perceived values that can differ from person to person and to the objective risks (Bockarjova and Steg 2014). The individual evaluation of the two appraisals ultimately results in the behavior of that individual. Figure 1 depicts the conceptual PMT model.

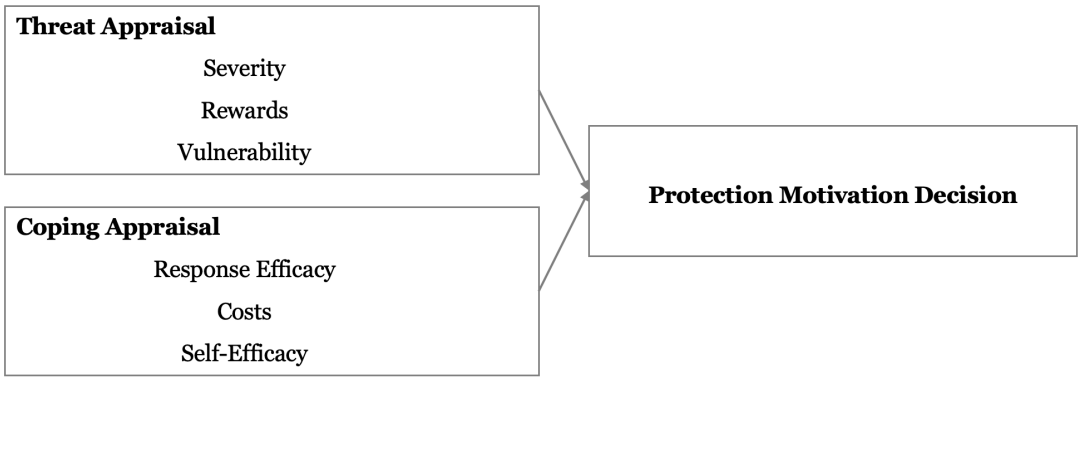

Figure 1. Conceptual PMT Model

So far, the PMT in the environmental sustainability domain has mostly been used to explain behavior to acute environmental risks like floods and wildfires (e.g., Bubeck et al. (2018)).

However, Bockarjova and Steg (2014) have successfully shown that the PMT can also be used to explain behavior in the face of slow-onset environmental risks like climate change. While the PMT has also been used in IS research, it has mostly focused on the information security literature (Cross et al. 2003; Menard 2014; Mou et al. 2017) to date. To the best of our knowledge, PMT has not yet been addressed in the Green IS literature. Since the PMT is promising in the environmental sustainability literature, we aim to fill this gap.

Hypotheses

In the following, we describe the hypotheses based on PMT regarding employees' motivation to engage in environmentally sustainable behavior. The operationalization of the PMT categories and the formulation of corresponding questionnaire items for our specific research context are based on validated models and are explained in more detail in the section on survey design.

The dependent variable in the PMT is the protection motivation decision. In the case of climate change, this can be translated to the motivation to take actions that protect the environment, in this specific case, the motivation to drive energy-efficiently. The other elements and relationships of the PMT can be interpreted in light of slow-onset environmental risks in the following way: Threat appraisal refers to the current behavior that amplifies climate change, in our case non-energy efficient driving. The individual's perception of how likely society is negatively affected by climate change translates to severity. If perceived severity is high, individuals should be more likely to engage in pro-environmental behavior, i.e., in energy-efficient driving. The second element of threat appraisal, the rewards, are connected to keeping current environmentally unfriendly actions. If the benefit of current behavior is high, the current instead of more environmentally friendly behavior will most likely be encouraged. The third element, vulnerability, measures if an individual perceives the effects of climate changes as harmful for the

own life and being. If the perceived vulnerability is high, the motivation to engage in protective actions should also be high. Thus, we hypothesize the following (depicted in Figure 2):

H1: Perceived (collective) severity positively influences an individual's motivation to engage in protective actions.

H2: Perceived rewards of current behavior negatively influence an individual's motivation to change their behavior towards more protective actions.

H3: Perceived (individual) vulnerability positively influences an individual's motivation to engage in protective actions.

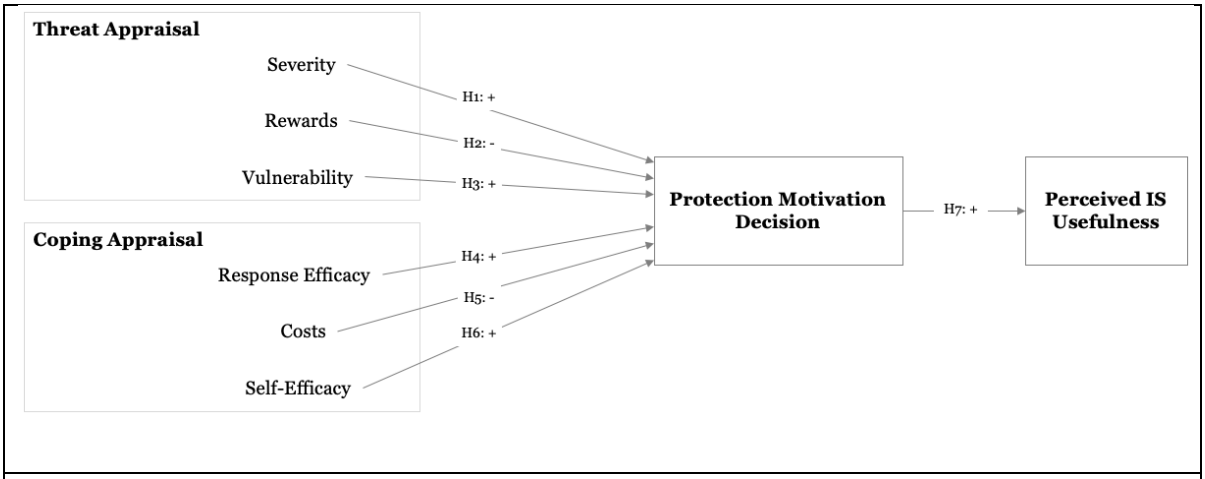

Figure 2. PMT Model and hypotheses regarding engaging in energy-efficient driving behavior

The second category of PMT, coping appraisal, is composed of response-efficacy, the belief that own actions have an influence on climate change. Response efficacy is expected to have a positive influence on the actions of individuals to engage in energy-efficient driving. The same is expected to be the case for self-efficacy, the belief of individuals in their own capabilities to behave

environmentally friendly. The third element of coping appraisal, response costs (usually non-monetary and monetary nature, while in the organizational context only the first applies to employees) should have negative effects on environmentally friendly behavior, as high costs to adopt environmentally friendly behavior curtails its implementation. This leads to the following hypotheses:

H4: Perceived response efficacy positively influences an individual's motivation to engage in protective actions.

H5: Perceived costs of current behavior negatively influences an individual's motivation to change their behavior towards more protective actions.

H6: Perceived self-efficacy positively influences an individual's motivation to engage in protective actions.

Lastly, we extend the conceptual PMT model with a measure to validate if the motivation for protective actions of employees increases the positive perception of Green IS in the organization, i.e., IS that foster environmental sustainability. If the motivation to take protective decisions and actions, in our case the decision to drive environmentally friendly, is high, we would also expect individuals to positively perceive the use of IS that support energy-efficient driving. Note that our experimental setting did not allow us to directly measure usage or ask for self-reported usage, as the organization has a directive in place that demands the usage of the Green IS. Thus, asking for actual usage of the Green IS would mean employees would have to admit their own noncompliance, which is unlikely to produce truthful answers despite the anonymity of the questionnaire. Therefore, we examine perceived usefulness of the Green IS which can serve as proxy for usage and hypothesize:

H7: Protection motivation decision of individual's positively influences the perception of Green IS.

If hypothesis seven holds true, we have identified a range of factors that drive perceived Green IS usefulness and thus can serve as guideposts when designing IS that aim at fostering sustainable behavior.

Research Design and Methodology

As the aim of our research was to test the applicability of a proven theory, the PMT, in a new context, we used a single case study. Case studies are an established methodology in IS research to investigate IS in specific contexts (Darke et al. 1998).We adopted a quantitative survey study with train drivers in a large railway organization to test our hypotheses. Prior to that, we conducted qualitative interviews with selected train drivers. Based on the insights from these interviews, we developed the quantitative survey to assess our model.

The following describes the survey design and data collection before providing details on the data analysis with information on the measurement and the structural model. Subsequently, the results of the structural model are presented, including an evaluation of the above posed hypotheses.

Survey Design and Data Collection

Our empirical site is a large railway company that is headquartered in Europe. In a first step, we explored motives for sustainability actions in a qualitative interview study, as qualitative research helps to better understand the reasons behind the action of people (Merriam and Tisdell 2016), in this case energy-efficient driving of train drivers. We chose an interview-based approach, as interviews are a good way to gather information about people's perceptions (Baumbusch 2010),

especially in a research context that is unknown. We conducted face-to-face interviews with ten train drivers in their working environment, on trains, using a semi-structured questionnaire. In the interviews, we explored the train driver's motivation for saving energy on the job, which range from doing something good for the environment to securing their own jobs.

Based on the information from the interviews, we developed a survey questionnaire to gather insights from a representative group of train drivers. The questions were formulated based on proven constructs from the PMT and examine how train drivers appraise threat and coping with climate change. We relied on survey items that are validated in research (Bockarjova and Steg 2014; Kothe et al. 2023; Rainear and Christensen 2017; Shafiei and Maleksaeidi 2020) to ensure content validity and adapted them to our context as little as necessary. To create buy-in from the organization and to get as many employees as possible to participate in the survey, we had to strictly limit the number of questions of our questionnaire. Nevertheless, in addition to questions targeting one of the elements of PMT, we included questions regarding demographics. Also, we included some contextual questions that are not covered by the PMT that have been shown to influence energy-efficient driving behavior of transportation staff (Strömberg and Karlsson 2013). We pre-tested our survey with employees (train drivers and their managers) in regions which were later not part of the actual survey. Based on the feedback of the pre-testers, we adapted the survey to ensure that the wording of the survey is in line with the employees' language, in particular with the technical terms used in the company in the right sense and context.

In the following, we provide more details on the design of the different PMT categories in our specific context. The severity dimension investigates the negative consequences of mankind's energy consumption for the planet and thus takes a collective view. The next dimension measures the rewards stemming from driving non-energy efficient, e.g., the joy of high acceleration. The

third and last dimension of threat appraisal investigates the individual vulnerability of train drivers, i.e., the perceived chance to experience negative impact on the own life due to climate change. In regard to coping appraisal, response efficacy takes a collective perspective on the impact that energy-efficient train driving can have on climate change. The response costs are individual costs that are occurred when driving energy-efficiently, which could be for example perceived loss of comfort, individuality and free expression that come with following instructions from an energy-efficient driving assistance system. The final dimension of coping appraisal, self-efficacy investigates the trust in own capabilities to drive energy-efficiently. The dependent variable in our model, the protection motivation decision, examines the importance that train drivers attribute to energy-efficient driving at their workplace. Finally, the perceived IS usefulness measures the attitude that train drivers have regarding existing digital energy-efficiency support systems. We use this measure as a proxy for IS usage, as it is not possible to measure actual IS usage data on an individual level due to data privacy and other concerns of the workers council.

The online-based survey was sent to approximately 250 train drivers in certain regions of the organization's operations. In total, 105 employees participated in the questionnaire. Asked for their gender, 90% of the respondents identified themselves as male, 8% as female and 3% did not want to specify their gender. The age of the respondents was mainly between 61 to 52 years (29%), followed by 51 to 42 years (26%), 41 to 32 years (24%), 31 to 22 years (13%) and the remaining 9% split between employees older than 61 and younger than 22 years. The largest group of respondents started working as a transportation staff ten years ago or less (54%). Table 1 provides an overview of the demographics.

Number of Respondents = 105						
Gender	*Male* 89.5%		*Female* 7.6%		*Not specified* 2.9%	
Age (Years)	*<22* 3.8%	*22-31* 13.3%	*32-41* 23.8%	*42-51* 25.7%	*52-61* 28.6%	*>61* 4.76%
Time as Transportation Staff (Years)	*<11* 53.55%	*11-20* 14.3%	*21-30* 14.3%	*31-40* 12.4%	*41-50* 2.9%	*51-60* 2.9%

Table 1. Demographics of Survey Respondents

Data Analysis: Measurement Model Evaluation

For our empirical analysis, we used structural equation modeling (SEM), based on the partial least squares (PLS) path modeling technique. PLS SEM is an appropriate technique for testing theories at early stages (Fornell and Bookstein 1982), such as the PMT in the domain of slow onset environmental risk and IS. The evaluation of the PLS path model follows two steps: First, the measurement model is validated by proofing the validity and reliability of the latent constructs. In a second step, the structural model is assessed (Henseler et al. 2009). We used the *seminr* package deployed in RStudio (version 4.2.1) for the model assessment. We started our analysis with questionnaires of 105 employees of which 87 results were complete and valid. Our sample size therefore exceeds the widely accepted "rule of ten" (Kim 2005), which states that the sample size should be at least the number of relationships of the most complex construct in the model times ten (Chin 1998), in our case 60 (six reflective indicators times ten). Each construct of our model

was measured using multi-item reflective indicators. We used the four concepts of indicator and construct reliability, and content and discriminant validity to validate our measurement model. The outcomes are reported in the following.

Reliability of the measurement is assessed on an indicator level and a construct level. The indicator reliability is examined by looking at the rate of an indicator's variance which is explained by its construct (Hair et al. 2021). In our model, all factor loadings are significant, and the loadings are sufficiently high, considering the recommended threshold of 0.707 (50% of variance explained) for factor loadings (Carmines et al. 1979; Chin 1998; Henseler et al. 2009). While loadings below that threshold can be obtained in some cases, all indicators with very low loadings (below 0.4) should be removed from the model (Hair et al. 2021). The construct reliability or internal consistency reliability is the extent to which indicators of one construct are related to each other. We use the composite reliability rho_C to measure the construct reliability (Jöreskog 1973). The composite reliability of the measures in our model (see Table 2) are sufficient, as the values are in the threshold range of 0.60 to 0.95 (Diamantopoulos et al. 2012).

The convergent validity refers to the convergence of a construct to explain the variance of its indicators and is measured with the average variance extracted (AVE) (Fornell and Larcker 1981). The AVE in our model is higher than the threshold of 0.5 for all constructs (i.e. more than 50% of the variance is explained). The discriminant validity evaluates if the different measurement items are distinct (Campbell and Fiske 1959). Since the square roots of the AVE are higher than the corresponding correlations of the constructs in our model (see Table 2), the criteria for discriminant validity (Fornell and Larcker 1981; Hulland 1999) is fulfilled. Table 2 displays the relevant values for the measurement model evaluation, i.e. the construct correlation matrix, the AVE, its square root and rho_C.

Construct	AVE	rho_C	1.	2.	3.	4.	5.	6.	7.	8.
1. Severity	0.79	0.88	**0.89**							
2. Rewards	0.73	0.85	-0.45	**0.86**						
3. Vulner-ability	0.86	0.92	0.57	-0.21	**0.95**					
4. Response Efficacy	0.79	0.94	0.58	-0.41	0.37	**0.89**				
5. Costs	0.63	0.77	-0.20	0.54	-0.23	-0.24	**0.79**			
6. Self-Efficacy	0.66	0.79	0.27	-0.21	0.28	0.23	-0.16	**0.81**		
7. Protection Motivation Decision	0.84	0.91	0.54	-0.55	0.14	0.64	-0.38	0.10	**0.92**	
8. Perceived IS Usefulness	1.00	1.00	0.23	-0.30	0.23	0.28	-0.19	0.04	0.31	**1.00**

Note: Column 1.-8. report square root of AVE on the diagonal (in bold) and construct correlations on the lower triangle

Table 2. Construct correlation matrix, AVE analysis and rho_C

Research Results: Structural Model Evaluation & Assessment of Hypotheses

As a first step of our structural model evaluation, we examine if collinearity issues exist. For this, we calculate the variance inflation factor (VIF). As all VIF values in our model are below 3 (highest VIF in our model is 2.167), we conclude that collinearity is not a problem in our model (Becker et al. 2015; Mason and Perreault 1991).

To determine the explanatory power of our model, we calculate the R^2 (Shmueli and Koppius 2011), which results in 0.59, meaning that 59% of the variance is explained in the endogenous constructs. In general, the obtained R^2 can be rated as moderate (Hair et al. 2011). However, in our specific research context as we measure human perceptions and intentions and not concepts that are inherently predictable (Hair et al. 2019), our R^2 reaches a highly satisfactory value. To test our hypotheses, we applied a bootstrapping technique. Assuming a 5% significance level, all relationships except one (from self-efficacy to protection motivation decision) are significant (see Figure 3). Response efficacy with 0.483 has the strongest impact on the protection motivation decision and is highly significant ($p<0.01$). Thus, our model confirms the hypothesized positive relationship (H4). Severity has the second strongest impact on protection motivation decision. The relationship is highly significant ($p<0.01$) and the positive relationship is in line with our first hypothesis (H1). Our model furthermore confirms the negative relationship of rewards and costs with protection motivation decision (H2 and H5), with both relationships being significant at the 5% level. However, their effect seems to be not as strong as the one of severity and response efficacy. For vulnerability, we see a significant result, however its influence on the protection motivation decision is unexpectedly negative (in H3 we assumed a positive relationship). The effect of self-efficacy on protection motivation decision is not significant. The positive

hypothesized relationship between protection motivation decision and the perceived usefulness of Green IS (H7) is confirmed by our model ($p<0.01$) and shows a strong effect.

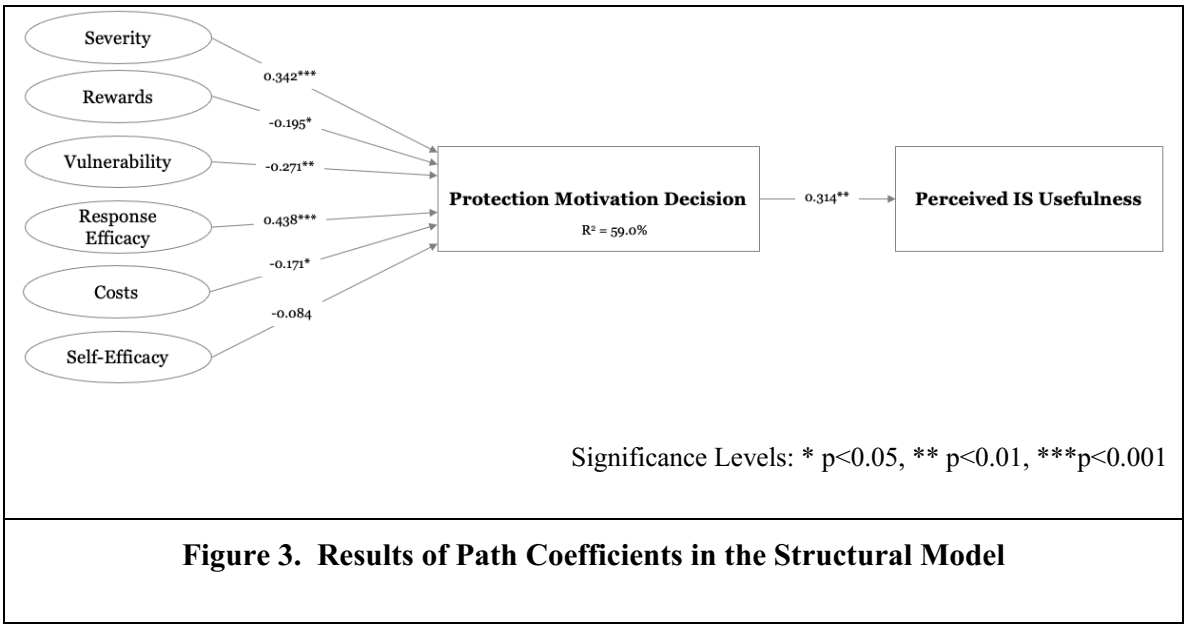

Figure 3. Results of Path Coefficients in the Structural Model

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Discussion and Future Research

The carbon footprint of companies – and transportation companies in particular – not only depends on investment decisions, but also to a large extent on employee behavior. Changing behavior in general, and of employees in specific is challenging, as relying on well-known structures and routines is always easier for individuals than increasing cognitive load to engage in new behaviors. IS have shown in the past, that they can assist in behavior change. However, for IS to successfully promote sustainable employee behavior, it needs to excel the existing motivation of employees to act green. Our presented study contributes to the understanding of the motivation of employees to engage in energy-efficient behavior. It furthermore proves that a higher motivation to engage in environmentally protective actions goes hand in hand with a higher perceived usefulness and thus usage probability of Green IS in organizations.

Our survey among transportation staff provides support for most hypotheses that we developed based on the PMT. The results reveal that especially response efficacy and perceived severity strongly influence the motivation of train drivers to engage in protective climate change behavior at work. Both dimensions are collective measures, i.e., response efficacy measures the perception if energy-efficient train driving generally helps to fight climate change and severity measures the perception of the severity of climate change for the planet (not for the individual employee filling out the survey). Other studies investigating the PMT and slow onset risk also see a strong relationship of response-efficacy and severity on protection motivation decision (Bockarjova and Steg 2014; Kothe et al. 2023) and thus substantiate our finding. On the other hand, rewards of current non-energy-efficient behavior as well as costs of energy-efficient behavior have a negative influence on the protection motivation decision.

The finding that vulnerability has a negative impact on individuals' decision to adopt protective climate change measures was surprising to us. Initially, we hypothesized that the belief to personally experience negative consequences in life because of climate change would drive individuals to engage in action. Our model, however, yielded opposing results. One plausible conjecture (in line with prior research) is a mismatch of collectivism and individualism in the context of climate change. The PMT originally focused on health risks (Rogers 2003, 1975), with the individual being the primary focus of attention. For example, in the context of smoking, if an individual perceives a threat from heavy tobacco consumption, only they themselves can take coping measures to address it (MacDonell (2013) provides an example of the PMT in the context of smoking). In contrast, decision-making in the context of climate change follows a different logic: even if individuals feel personally threatened by climate change, they do not necessarily need to take action themselves to mitigate the threat. Instead, they can rely on others to act and

reduce the impact of climate change. Furthermore, individuals can downplay the threat by acknowledging that all people on the planet will be affected by climate change to some degree. While this explanation is only one possible interpretation of the negative relationship between vulnerability and the protective motivation decision, other studies investigating climate change with the PMT have found a similar relationship. For instance, Bockarjova and Steg (2014) also identified a negative relationship in one of their models examining private household electric vehicle adaption.

For the relationship of self-efficacy and protection motivation decision, we were unable to find a significant relationship. This might be due to the complexity of the construct and due to the fact that we were not able to include the full self-efficacy scale in our survey due to the strong restrictions regarding the length of our questionnaire (see above). While the original self-efficacy scale has 17 items (Sherer et al. 1982), simplified scales today still have a multitude of items (e.g., Chen et al. (2001) propose an eight-item measurement). Furthermore, no specific scale exists that measures self-efficacy in this particular context; thus, we had to rely on and adapt a general self-efficacy scale. Adding up those factors probably led to the missing significance of the factor.

All in all, the PMT has proven to be a successful theory for the explanation of green behavior of employees in general and in the context of IS in specific. This success manifests in several contributions to theory and practice that our study entails, which are described subsequently.

Contributions to Theory and Practice

Environmental sustainability and Green IS have become increasingly important areas of research in recent years. Our study is the first one to investigate motivational affordances of employees in the light of slow onset environmental risks and IS. We apply the PMT to environmental

sustainability behavior in the IS domain and showcase with our study that the PMT is a suitable theory to explore motivational affordances of employees in this domain. Our results underline the importance of investigating the role of collective and individual considerations in the context of climate change and are in line with psychological literature stressing the importance of those considerations (Lindenberg and Steg 2007; Steg and de Groot 2012) when investigating environmental risks. In sum, our study highlights the relevance of the PMT for Green IS research, which can act as a helpful theory when designing and evaluating IS to foster environmental sustainability.

Moreover, our study provides insights relevant to practice. Our in-depth interviews and the survey revealed participants' perspectives on environmental sustainability and implications for their work, themselves, and their organizations. Based on these insights, we can draw conclusions about motivational affordances of transportation staff that are relevant for practice: We found that the severity of climate change, which is accelerated by emissions in the transport sector, as well as response efficacy play a critical role in employees' urgency to act climate friendly. This urgency furthermore accelerates the positive perception of IT systems that support environmental sustainability. Therefore, highlighting the severity of climate change and the response efficacy in the work context can be an effective strategy to promote environmental sustainability among employees. Green IS can serve as a means to pursue this strategy in organizations at scale and at low cost. Our results thus inform the design of Green IS aiming at promoting sustainable employee behavior.

Limitations and Future Research

Our study provides valuable insights into the motivational affordances of employees related to environmental sustainability and IS. However, there are some limitations to our study setup that

need to be acknowledged and can serve as a starting point for future research. Firstly, the number of responses to our survey was limited, which may affect the generalizability of our findings. As employees of the organization participated voluntarily in our survey, the external validity is limited due to the self-selection bias of survey participants.

The findings in our setting, as well as in literature, stress the importance of the role of collective and individual motivational affordances. Future research should investigate this differentiation in greater detail. Additionally, it could also be beneficial to compare the effectiveness of PMT with other theories, such as the theory of planned behavior, to identify the most effective theory to use in designing IS to foster environmental sustainability.

Our area of investigation is promising for future research: Studying the behavior of train drivers has a major advantage compared to other transportation staff working on the road. Physical conditions on the rail are relatively stable and allow for repeatable field tests. Field experiments on the road, on the other hand, are considered inaccurate because they depend largely on external conditions and are therefore less repeatable than laboratory experiments (Huang et al. 2018). Thus, future research with transportation staff could explore motivational affordances and IS usage further with real-world data from the field. Our focus on one specific industry on the other hand might limit our findings. Employees in the transportation sector have a high lever on energy usage and thus, their perspective on energy-efficient behavior might be different than in other professions (e.g., office workers). Also, the preconditions regarding job identification, education level and age, degree of task repetitiveness, and environmental attitudes might be different in other professions. Thus, future studies should validate our findings in organizations in other sectors.

Our findings provide practical guidelines for organizations that seek to promote environmental sustainability in the IS domain. In the future, digital interventions that target the motivation of

employees to act environmentally friendly at work should be designed to specifically address severity and response efficacy. The success of such interventions should be demonstrated in practice.

Conclusions

In this paper, we used PMT to elaborate on motivational affordances of employees to act in an environmentally sustainable manner. Our findings inform the design of IS that support behavior change of skilled workers to save energy at work. In specific, we investigated the motivation of transportation staff to drive energy-efficiently, and the perception of Green IS in their organization. In our use case, train driving, Green IS have the potential to induce large reductions in carbon emissions by changing driving behavior. If digital feedback interventions address the motivational affordances of drivers, they hold promise for generating significant energy efficiency improvements in the driving cabin. This is particularly true given their capacity to scale and integrate into existing systems.

To conclude, our study showcases the potential of PMT to explain employee's behavior in the context of slow-onset environmental risks and relates it to Green IS perception in organizations. The study proves the relevance of PMT and its importance for future research.

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