The Digital Workplace:

Antecedents and Consequences of Technostress

Dissertation

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"There is nothing either good or bad,

but thinking makes it so."

– William Shakespeare, Hamlet

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Abstract

Digital transformation has a large impact on organizations, affecting their ways of doing business. This development offers many opportunities, for example products and services can be offered in less time, and costs can be reduced. By enabling new forms of collaboration, new markets can be tapped with innovative digital products and solutions.

Digital technologies are the major driver of digital transformation. As they found their way into organizations, it did not only influence business models, but the conditions of work have changed tremendously. Todays' workplaces are digital workplaces that are no longer bound to a certain location or time. While smart workplace technologies facilitate business processes and increase the productivity of the workforce in the digital age, research has shown the potential of digital technologies to cause technostress, a specific form of stress that is perceived by end-users of information and communication technologies. Technostress is considered the dark side of digital transformation.

The research papers included in this dissertation, investigate technostress to understand how organizations can enhance and retain the productivity/performance of their employees under the umbrella of digital transformation by avoiding technostress. It allows researchers and practitioners to design and analyze measures countering technostress.

The articles contribute to the following current research streams on technostress: environment technology conditions, technology driven spillover effects of demands into the private domain, coping and the mitigation of technostress, and stress outcomes. After evaluation antecedents and consequences of technostress, the last article closes the bracket around the dissertation, proposing an extension of the concept of technostress as a new conceptualization of stress due to digital technology use that fits the new socio-technical context of digital work.

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Part I. Theoretical Frame and Motivation

1. Introduction

Digitalization rapidly changed and continues to change many areas of live, driven by a wide variety and fast implementation of technologies which has led to multifaceted changes for individuals, economies, and society[1] (Fitzgerald et al., 2013; Gimpel et al., 2018). Our world undergoes tremendous changes as ever new technologies evolve. The term digital transformation expresses that our activities are moving into the digital space. Scholars even talk about the “digital age” (Attaran et al., 2019) describing these disruptive times as a new historical era. In the business context, “digital transformation affects the whole company and its ways of doing business” (Verhoef et al., 2021, p. 891). Digital technologies are the major driver of digital transformation. (cf. Verhoef et al., 2021, p. 890).

1.1. Digital Transformation

The conditions of work and doing business have changed considerably with new socio-technical developments. Changes attributed to the ongoing digitalization concern employees, the organization and even economic environments (Attaran et al., 2020). Emphasizing the magnitude of transformation, Figure 1 contrasts working and business environments in the digital and the industrial age. In the industrial age, work was characterized by repetitive tasks, rigid output expectations and hierarchical structures as well as low uncertainty and predicable market developments. Today, work has become fast and agile, with digital technologies helping reduce costs and increase efficiency, empowering “employees to work faster and communicate more easily” (Attaran et al., 2020, p. 392). Workforces are small and connected through the technological capabilities and organizations have become internetworked. Employees can “easily share their ideas, thoughts, and content” (Attaran et al., 2020, p. 386), and in

[1] Excerpts of this chapter have been taken from the research papers that are part of this thesis. For better readability, I omit the separate declaration of each sentence.

consequence, knowledge networking is on the rise in the organization. Digital transformation can also be defined "as a change in how a firm employs digital technologies, to develop a new digital business model that helps to create and appropriate more value for the firm" (Verhoef et al., 2021, p. 889).

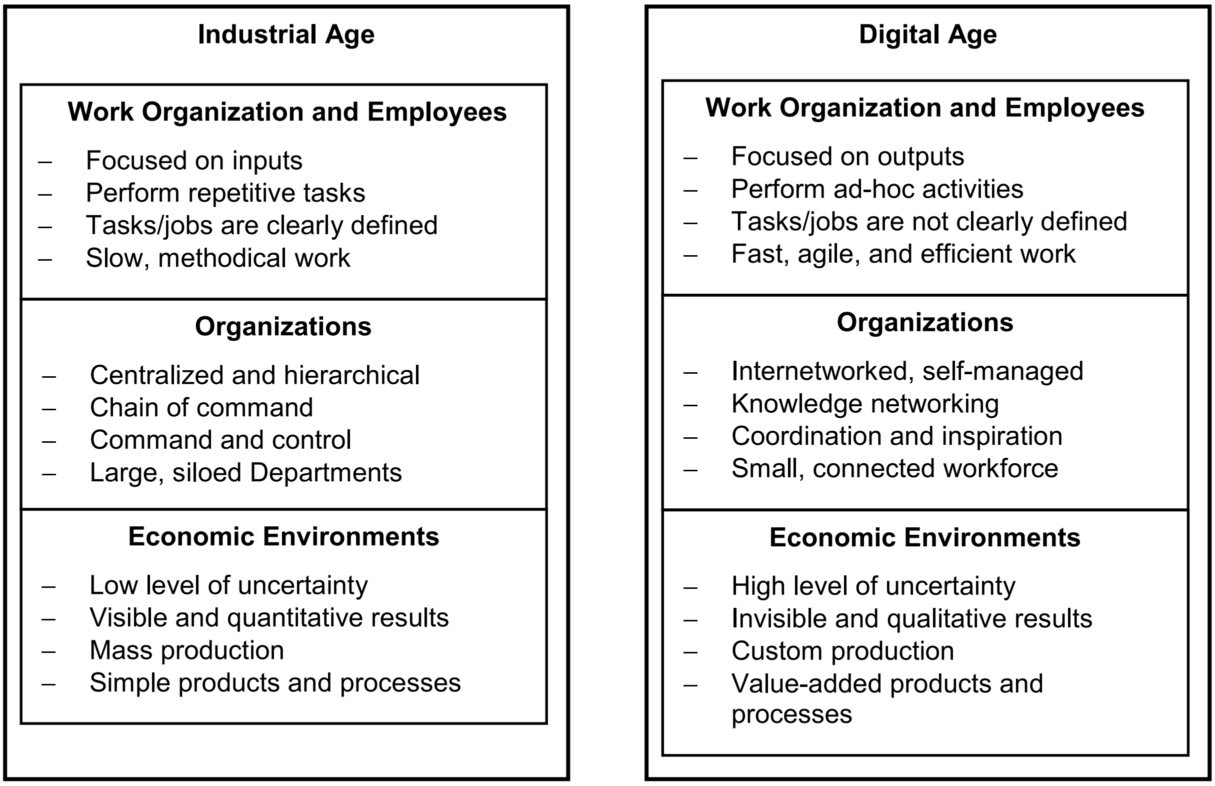

Figure 1. Characteristics of the Industrial vs. the Digital Age. Taken and Adapted from (Attaran et al., 2020, p. 386).

Accordingly, the focus is on value-added products and processes and custom production (cf. Figure 1), offering firms great potential for innovative business models, growth and new forms of collaboration.

1.1.1. Digital Workplaces

These developments (cf. Figure 1) also affect the workplace as digital technologies have found their way into organizations. They facilitate business processes and provide efficient communication and collaboration tools, "increasing the productivity of the workforce in the information age" (Attaran et al., 2019, p. 1). Digital technologies are fundamental in digital workplace because they remove barriers through the connection of people, processes, and information (Attaran et al. 2020). Their use transforms the workplace from a narrowly defined and time- and location-bound place towards a virtual and digital workplace (Zuppo, 2012). It means that work is no longer bound to the physical space, decentralizing the traditional office (Attaran et al., 2019). The term remote work is often used to describe this form of labor (Hafermalz & Riemer, 2021; Molino et al., 2020; Wang et al., 2021). The COVID-19 pandemic has greatly accelerated this development in the past year. One reason is that the introduction of home office has proven to be an effective way to reduce personal contacts (Fadinger & Schymik, 2020; Molino et al., 2020) which affected many workplaces where it had not been a standard previously. Hence, work did not only become more technology-based but is increasingly relocated (into the private sphere in case of home office) (Allen et al., 2021).

Accordingly, digital technologies make businesses more agile and competitive, and help employees be more effective (Attaran et al., 2019, 2020). At the same time, digital workplaces are an advantage in the battle of the pandemic (Fadinger & Schymik, 2020).

1.1.2. Knowledge Work

One aspect that also drives digital transformation since its introduction, is the world wide web with the accompanying technologies (e.g., broadband internet, smartphones, cloud computing, etc. (Verhoef et al., 2021)). Information is accessible in a previously unknown extent through the internet and widespread use of digital technologies. While organizations have become internetworked (cf. Figure 1), simultaneously, information became a key resource for companies (Attaran et al., 2020) and the importance of knowledge as economic resource has grown (Pyöriä, 2005).

"Work that requires information to be executed, and in which information often determines the outcome" (Attaran et al., 2020, p. 384)[2] or is the product of the work, can be labeled knowledge work (Klotz, 1997; Pyöriä, 2005). Knowledge work heavily relies on digital technologies. The pandemic has made remote work for knowledge workers "the new normal" (Cho & Voida, 2020, p. 1).

Summarizing all these developments, the context of work has considerably changed. New forms of labor like knowledge or remote work are on the rise. Collaboration is possible in new forms and dimensions through digital technologies providing potential for productivity and innovation. However, these agile environments also place new demands on employees.

1.2. Technostress as Dark Side of Digital Transformation

Besides the positive effects of the use of digital technologies[3] (including an increase in productivity, effectiveness, and efficiency (Bharadwaj, 2000; Melville et al., 2004)), research has shown the potential of digital technologies to cause technostress, as a specific form of stress that is perceived by end-users of digital technologies (Brod, 1984; Ragu-Nathan et al., 2008). This is referred to as technostress in scholarly literature (Tarafdar et al., 2007; Tarafdar et al., 2019). Technostress is associated with negative consequences for the well-being of the individual, job performance of employees (Ayyagari et al., 2011; Califf et al., 2020; Khaoula et al., 2020; Tarafdar et al., 2019) and reduced innovation (Chandra et al., 2019).

Thus, technostress is of interest for research, as well as for organizations, employers, and employees because it counteracts the gain on productivity of the workforce through digital transformation and the introduction of digital technologies. It is especially relevant as the digital

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[2] Please note that Attaran et al. (2020) used the terminology "information work". However, I will use the term knowledge work as information is also knowledge at the same time. There is no clear consensus on the term and authors continue to use both interchangeably (cf. Cho & Voida, 2020; Deepa et al., 2015; Pyöriä, 2005).

[3] In this thesis, I will use the term digital technologies instead of information and communication technologies (ICT) even though the two terms are often used interchangeably in the literature. By this choice I want to emphasize the broad range of technologies that may be subsumed under the term and emphasize the close relation to the digital workplace. A definition of ICT can be found in Zhang et al. (2008).

workplace becomes standard with rising numbers of remote working employees due to the pandemic (Fadinger & Schymik, 2020; Molino et al., 2020). Digital work that largely relies on the use of information and communication technologies is even considered the "new normal" (Bondanini et al., 2020). While knowledge is a key resource for organizations, at the same time the majority of knowledge workers have reported to experience stress as a results of the technological changes (Deepa et al., 2015).

2. Motivation for Writing this Thesis

Given the importance of the topic, the presented dissertation focuses on the investigation of technostress as dark side of digital transformation. It is important to understand how organizations can enhance and retain their productivity and performance under the umbrella of digital transformation by avoiding technostress. A conceptualization of stress due to digital technology use that fits the new socio-technical context of digital work is important to understand the resulting psychological strain and its organizational and personal consequences. It allows researchers and practitioners to design and analyze measures countering technostress.

Further, studying stress and thereby aiding organizations to design healthy workplaces and achieve an improvement of mental health and well-being of employees is also personal and professional motivation for this research, considering my background as psychologist. Research on technostress originates from the field of Information Systems (IS) (Tarafdar et al., 2007). However, due to its relevance for organizations and employees, the topic has attracted attention in other fields like psychology or business research as well, that have recognized the importance of the phenomenon. Tarafdar et al. (2019) emphasize the need for interdisciplinary framing in technostress research as the phenomenon "has emerged based on multiple streams of thinking." (Bondanini et al., 2020, p. 2).

This work wants to contribute to the multidisciplinary investigation of the topic, making references to literature from all three domains in the respective papers, integrating them to gain a rich understanding of the topic. Being supervised at the Chair of Marketing and Innovation at the University of Bayreuth, this thesis is situated on the frontier between the disciplines psychology, IS and business research. The fields can benefit from a multifaceted view and reciprocal theoretical enrichment (Tarafdar et al., 2019) as there is a "need for greater disciplinary cooperation between the psychological and technological approach to technostress" (Bondanini et al., 2020, p. 13).

In the following paragraphs, the reader is introduced to the theoretical background and current research streams in the context of which the papers and their research contributions are placed. To conclude, the structure of the thesis is explained.

3. Theoretical Background

The term technostress was already coined in the 1980s when Brod (1982, 1984) spoke about the human cost of the computer revolution in his book. At that time, most digital technologies that we use on daily basis today, were not yet invented or still in their infancy. The scholarly perspective of technostress was shaped more than two decades later by seminal papers like Tarafdar et al. (2007), Ragu-Nathan et al. (2008), and Ayyagari et al. (2011). Many consider the work by Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) the standard concept of technostress (e.g., Benlian, 2020; Califf et al., 2020).

3.1.1. The Technostress Framework

The core-framework centers on a misfit of demands arising from digital technology use and a person's resources to cope with these demands based on the transactional theory of stress (Lazarus & Folkman, 1984, 1987). According to Tarafdar et al. (2007), five specific factors related to the use of digital technologies which can trigger technostress, exist: overload, invasion, complexity, insecurity, and uncertainty. These are referred to as technostress creators (see Table 1) or techno-stressors, respectively.

Table 1. Definition of the Five Core-Technostress Creators from the Framework by Tarafdar et al. (2007, p. 315)

Technostress Creator	**Definition**
Techno-Overload	“Techno-Overload describes situations where [digital technologies] force users to work faster and longer.”
Techno-Invasion	“Techno-Invasion describes the invasive effects of [digital technologies] in terms of creating situations where users can potentially be reached anytime, employees feel the need to be constantly ‘connected’, and there is blurring between work-related and personal contexts.”
Techno-Complexity	“Techno-Complexity describes situation where the complexity associated with [digital technologies] makes users feel inadequate as far as their skills are concerned and forces them to spend time and effort in learning and understanding various aspects of [digital technologies].”
Techno-Insecurity	“Techno-Insecurity is associated with situations where users feel threatened about losing their jobs as a result of new [digital technologies] replacing them, or to other people who have a better understanding of the [digital technologies].”
Techno-Invasion	“Techno-Invasion refers to contexts where continuing changes and upgrades in an [digital technology] unsettle users and create uncertainty for them, in that they have to constantly learn and educate themselves about the new [digital technology].”

Note. The term ICT in the original definition has been replaced through “digital technologies” for reason of consistency.

Going beyond the core-framework, further demanding aspects for employees attributable to the use of digital technologies have been identified. With various digital tools providing countless (new) communication channels, disruptions in the workflow through incoming messages have a reached an unprecedented frequency. The stress creating potential of recurrent interruptions has been shown in an information technology context (Galluch et al., 2015). Other disturbances that demand employees are related to unreliability such breakdowns or hassles (Riedl et al., 2012) which can be classified as stressful event (Braukmann et al., 2018) in daily use of digital technologies. If users are unsure whether it is their responsibility to solve those occurring technical issues, or their priority should rather be on work task, role ambiguity can arise. Ayyagari et al. (2011) added this confusion or “ambiguity on which tasks to perform” (Ayyagari et al., 2011, p. 841) side by side with work-overload and job-insecurity to the list of stressors. Moreover invasion of privacy is mentioned in this place (Ayyagari et al., 2011). Even though the terms sound quite similar, it should not be confused with techno-invasion (Tarafdar et al., 2007). It “involves the perception that an individuals’ privacy has been compromised” (Ayyagari et al., 2011, p. 834) due to technical possibilities and digital traces an users leaves while navigating in various systems.

3.1.2. Antecedents of Technostress

As shown above, there are several situations or events linked to the use of digital technologies at the workplace which demand employees and that can trigger technostress. Researchers have early focused on the questions what leads to those situations. This is subsumed under the examination of antecedents of technostress.

Ayyagari et al. (2011, p. 832) for example, investigated “which characteristics of technologies create stress” (cf. Figure 2), as aspects inherent to the technologies themselves.

Figure 2. Technostress Framework by Ayyagari et al. (2011).

Six characteristics of digital technologies that are categorized in usability, dynamic, and intrusive features, were identified (Ayyagari et al., 2011). Usability features are usefulness, complexity, and reliability. The single dynamic feature is the pace of change. Intrusive features are presenteeism and anonymity. While dynamic and intrusive features are related to perceiving higher levels of stressors, usability features are partly associated with lover levels of stressors.

Further, research has also identified several organizational and individual factors influencing the perception of technostress in negative or positive direction. For example, Ragu-Nathan et al. (2008) investigated three situational factors and organizational mechanisms: technical support, literacy facilitation (users are encouraged to share their experiences with and knowledge about new technologies), and involvement facilitation (users are consulted in the implementation of new technologies and are actively encouraged to try them out). These so called "technostress-inhibitors" operated as moderators of the relationship between techno-stressors and job-satisfaction, organizational commitment, and continuance commitment. Other factors that influence the relationship between techno-stressors and outcomes are timing control and method control (Galluch et al., 2015).

Individual factors include technology self-efficacy (Tarafdar et al., 2015), mindfulness (Pflügner et al., 2021) and personality traits like the big five openness, agreeableness, neuroticism, conscientiousness, and extraversion (Srivastava et al., 201 (Pflügner et al., 2020). For instance, six combinations or profiles of the five big personality traits are identified that put users at risk of perceiving technostress, while two personality profiles were identified that are beneficial meaning they are connected to perceptions of low techno-stressors (Pflügner et al., 2020).

3.1.3. Consequences of Technostress

Technostress arises, in line with appraisal theory on stress (Lazarus & Folkman, 1984, 1987), when the demanding situations (i.e., technostress creators) that occur during technology use are perceived as threatening for the well-being and the resources to handle the situation are appraised as non-sufficient (Tarafdar et al., 2007). Tarafdar et al. (2007) emphasize that "in the organizational context, technostress is caused by individuals' attempts and struggles to deal with constantly evolving ICT and the changing physical, social, and cognitive requirements related to their use" (p. 304).

The adverse psychological, physical, or behavioral responses that result from technostress are designated as (techno)strain (Atanasoff & Venable, 2017). Many such detrimental consequences of technostress have been identified. In this context, several studies have dealt with different facets of strain like mental exhaustion (i.e., feeling burned out and drained (Ayyagari et al., 2011; Srivastava et al., 2015)), or problems of psychological detachment (Barber et al., 2019; Santuzzi & Barber, 2018). Furthermore, technostress is also associated with adverse organizational outcomes (i.e., lower productivity (Tarafdar et al., 2007; Tarafdar et al., 2015), lower user satisfaction (Fischer & Riedl, 2020), and lower employee's loyalty to the employer (Tarafdar et al., 2011)). The most recorded strain is the negative effect on end-user satisfaction, followed by job satisfaction, performance, productivity, and organizational commitment (Sarabadani et al., 2018). Hence, tackling the occurring technostress is of great importance for organizations.

3.1.4. Contemporary Research Streams

Contemporary research in the field of technostress deals with topics such as coping (e.g., Pirkkalainen et al., 2019; Tarafdar et al., 2020), stress outcomes (e.g., Chen et al., 2019; La Torre et al., 2020), technology environment condition (i.e. characteristics of technologies and the design of stress-sensitive systems) (e.g., Adam et al., 2017; Jimenez & Bregenzer, 2018; Tarafdar et al., 2019), spillover of demands into the private domain driven by technology (Benlian, 2020), and challenge vs. hindrance stressors (Benlian, 2020; Califf et al., 2020; Tarafdar et al., 2019). The last topic came to debate through the observation that technostress creators are also associated with positive outcomes including challenges, high performance, learning, personal growth, and positive emotions (Benlian, 2020; Califf et al., 2020; Tarafdar et al., 2019). In account of this observation, there is a vital ongoing scholarly discussion about appraisal of the technostress creators and concepts of techno-eustress vs. distress (Benlian, 2020; Tarafdar et al., 2019). However, the focus of this thesis is on the dark side of technostress as it endangers the benefits of digital transformation for organizations.

Current research also investigates the phenomenon in private settings as well (see, e.g., Maier, Laumer, & Eckhardt, 2015; Maier, Laumer, Weinert, & Weitzel, 2015; Tarafdar et al., 2020). Due to its relevance for both employees and employers, the primary focus is on technostress in work-specific contexts within this dissertation.

4. Context of the Research Papers and Thesis Organization

These research foci are valuable and essential since it is the appraisal of technostress creators and the application of coping measures that determine the extent to which employees experience technostress and its negative consequences. At the same time, however, it is also crucial to examine how the working life has changed and how this affects technostress creators, their perception by employees, and the appropriate prevention and coping measures in the digital workplace. More than 10 years have passed since the seminal works which shaped our understanding of technostress (Ayyagari et al., 2011; Ragu-Nathan et al., 2008; Tarafdar et al., 2007), were published. Only an up-to-date understanding of digital work demands that create stress allows one to study appraisal, coping, outcomes, and system design concerning these demands.

Figure 3 displays the contextual frame of the research papers included in the dissertation visually. Against the backdrop of progressing digital transformation, the presented work focuses on *the digital workplace* and especially on technostress as negative outcome for employees resulting from the use of digital technologies. In this context, *antecedents* (individual and technological) *and consequences of technostress* are examined and discussed to conclude with an evaluation of the concept technostress itself. Other authors also raise the question whether the present concept of “technostress” is still up to date (Fischer et al., 2019). This question is addressed through the proposal of an extension of core framework to keep pace with ongoing (socio-technical) developments through the course of digitalization.

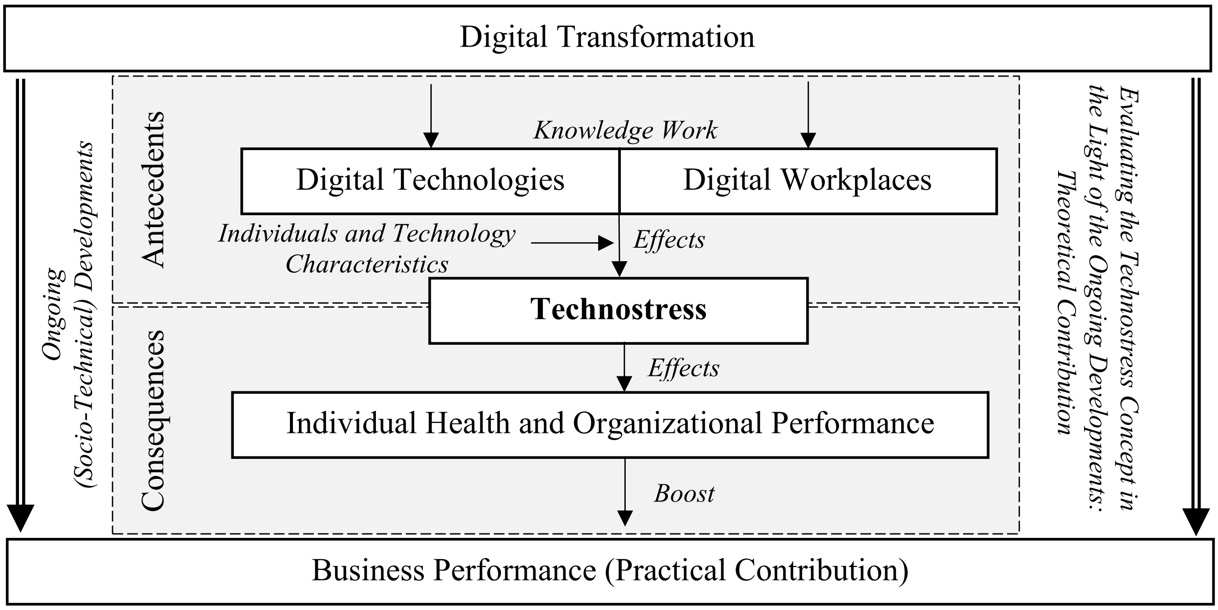

Figure 3. Contextual Frame of this Dissertation: Investigation of Antecedents and Consequences of Technostress in View of Ongoing Digital Transformation.

In details, the research papers address the following aspects of the currents research streams on technostress:

The first research article *"Considering Characteristic Profiles of Technologies at the Digital Workplace: The Influence on Technostress"* closely relates to the technostress framework of Ayyagari et al. (2011). It is a mixed-methods study, as described by Venkatesh et al. (2013). It includes and integrates qualitative as well as quantitative investigations, which, according to Venkatesh et al.'s (2013) scheme, serve developmental purposes. The manuscript advances the knowledge about typical characteristics of digital technologies, their interplay, and the influence on technostress. Instead of investigation only the influence of single technologies, the portfolio of each workplace of the subjects in the questionnaire was computed based on the characteristic profiles of the single technologies for the investigation of technostress. Profiles of the typical characteristics of more than 25 common workplace technologies are provided.

While the initial paper is closely tied to the digital workplace and the technologies themselves, a deep dive into further antecedents of technostress is taken within the second paper titled *"Segmentation Preference and Communication Technology Adoption: The Boundary Transcending Effects of Technostress"*. Following the call by Benlian (2020) the technology-driven spillovers from work into the private domain are illuminated. A study with data assessed at two different time points during the corona virus pandemic was conducted as Benlian (2020) further highlights the need for longitudinal investigations because many insights on technostress are based on cross-sectional data. In the paper, we concentrate on the effects between boundary management, technology use, technostress, and role conflict, which are also important topics in psychological research, highlighting the interdisciplinarity of this dissertation. In longitudinal SEM design, we focus on showing the causal relationship between these variables. Even though it is the second article in the logical order, this paper was the last one written in chronological order.

Within the third research article named *"Mitigating the Negative Consequences of ICT Use: The Moderating Effect of Active-Functional and Dysfunctional Coping"*, consequences of technostress are investigated contributing to the current research stream on coping (e.g., Pirkkalainen et al., 2019; Tarafdar et al., 2020) – and appealing the call by Tarafdar et al. (2019) for further inter-disciplinary technostress research. In a cross-sectional study, based on a subsample of data from German knowledge workers, the relationship between technology related demands, exhaustion, productivity, and two coping strategies was investigated. With the Job Demand Resources Model (JD-R) as theoretical foundation (Demerouti et al., 2001), current psychological theory applied to explain the relationships between variables.

Lastly, the fourth research article with the title *"Extending the Concept of Technostress: The Hierarchical Structure of Digital Stress"* closes the bracket around this dissertation. We applied a sequential qualitative-quantitative mixed-methods research design. Based on theoretical reasoning and empirical data, we present a holistic framework of twelve demands from work practices relating to digital technology use and present a valid and reliable survey-based measurement model for the demands. Further, we embed the hierarchical model of demands from digital work in a nomological net showing the work and health-related effects. Finally, given the magnitude of change regarding the considered stress creators and the context of digital transformation – we suggest the concept of “digital stress” as an update and extension of technostress.

The dissertation is of cumulative nature and most research was conducted in the context of the research project “PräDiTec – Prävention für sicheres und gesundes Arbeiten mit digitalen Technologien” which was funded by the German Federal Ministry of Research and Education under grant agreement number (02L16D035). The research articles draw on data collected at different time points within the project. Referring to good scientific praxis, even though many responses were collected at one time of data acquisition, different variables and constructs are used and analyzed within the single papers. The only exception are the five technostress creators (Tarafdar et al., 2007) which are used either as dependent variable (DV) or as independent variable (IV). Table 2 summarizes the most important information about the research articles included in this dissertation.

Table 2. Overview of the Research Papers Included in this Thesis.

Title	**Authors**	**Content**	**Sample**	**Design and Methodology**
Considering Characteristic Profiles of Technologies at the Digital Workplace: The Influence on Technostress	Becker, J., Berger, M., Gimpel, H., Lanzl, J., & Regal, C.	Antecedents of technostress: 10 technology characteristics	n_1 = 15 expert interviews n_2 = 33 participants in 6 focus group sessions n_3 = 5005 questionnaire respondents	• Mixed-methods research • Qualitative analyses • SEM
Segmentation Preference and Communication Technology Adoption: The Boundary Transcending Effects of Technostress	Becker, J. & Lanzl, J.	Antecedents/consequences of technostress: • Segmentation preference • Technology adoption • Work-family conflict	n_4 = 637 questionnaire respondents from n_3 that were interrogated a second time n_5 = 637 questionnaire respondents from n_3 that were interrogated a third time	• Longitudinal study • Multigroup analysis • SEM
Mitigating the Negative Consequences of ICT Use: The Moderating Effect of Active-Functional and Dysfunctional Coping	Becker, J., Derra, N. D., Regal, C., & Kühlmann, T. M.	Consequences of technostress: • Active-functional and dysfunctional coping • Exhaustion and job-performance	n_3 = 3,362 subsample of knowledge workers from the questionnaire respondents	• Cross-sectional study • SEM
Extending the Concept of Technostress: The Hierarchical Structure of Digital Stress	Gimpel, H., Lanzl, J., Regal, C., Urbach, N., Becker, J. Kühlmann, T. M., Certa, M., & Tegtmeier, P.	Consequences /conceptualization of the framework of technostress: • 12 demands from digital work (i.e., the five core technostress creators plus seven newly identified stressors) • Exhaustion and job satisfaction	n_1 = 15 expert interviews n_2 = 33 participants in 6 focus group sessions n_3 = 5005 questionnaire respondents	• Mixed-methods research • Qualitative analyses • SEM

Note. *n_1, n_2 and n_3 are labelled chronology by the time order of data collection.

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Part II. Research Papers

1. Considering Characteristic Profiles of Technologies at the Digital Workplace: The Influence on Technostress

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Abstract:

Workplaces develop more and more to digital workplaces. However, this may lead to technostress. An understanding of the profiles of technologies used at the digital workplace, their interplay, and how they influence technostress is valuable as it can assist developers of technologies and designers of workplaces to prevent technostress. Therefore, we analyze literature and conduct expert interviews to identify ten characteristics of digital technologies that relate to technostress. By analyzing data from 4,560 employees, we evaluate the characteristics. Furthermore, we develop characteristic profiles of multiple technologies used at the respondent's digital workplace. Lastly, we investigate their influence on technostress creators using structural equation modeling. We find that the different portfolios of technology profiles influence technostress creators in different manners. Our contributions are identifying additional characteristics of digital technologies, showing the importance of investigating workplaces as a whole, and highlighting design opportunities for health-oriented workplaces that alleviate technostress.

Keywords: Digital technologies, characteristics of digital technologies, digital workplace, technostress, digital stress, mixed methods research, structural equation modeling

1.1. Introduction

Digitalization, driven by a wide variety of digital technologies, has led to multifaceted changes for individuals, economies, and society (Fitzgerald et al., 2013; Gimpel, Hosseini, et al., 2018). Digital technologies are ubiquitous in private but also in business lives. They have changed the workplace from a narrowly defined and time-bound place to a partly virtual and temporally and locally independent existence (Zuppo, 2012). At the beginning of the year 2020, the COVID-19 pandemic led to the imposition of confinement or contact restrictions in many countries. Work was transferred to home offices where possible. For many, this meant a new level of virtual work. This may have a long-term impact on the equipment of many workplaces with digital technologies and their use even after the end of the pandemic.

Digital technologies include devices like smartphones or tablets but also applications that can facilitate business processes by providing tools for inter- and intra-organizational communication and collaboration (Zuppo, 2012). Today's workplace does not only consist of a single digital technology but many, which enable effective ways of working, defined as a digital workplace (Gartner, 2020). The design of the digital workplace has become an important factor in increasing the productivity of knowledge workers (Köffer, 2015). However, the increased usage of digital technologies in the changing world of work may cause stress, leading to potentially negative reactions in individuals. Research has noted this specific form of stress as technostress, (Ayyagari et al., 2011; Tarafdar et al., 2007; Tarafdar et al., 2011; Tarafdar et al., 2019) which has first been introduced by clinical psychologist Craig Brod as "a modern disease [caused by one's] inability to cope with new computer technologies in a healthy manner" (Brod, 1984, p. 16).

In the last years, researchers focused on different aspects of technostress including technostress creators (e.g., Tarafdar et al. (2007), strains (e.g., Gimpel, Lanzl, et al. (2018)), technostress inhibitors (e.g., Ragu-Nathan et al. (2008) and coping behaviors (e.g., Pirkkalainen et al. (2019)). Ayyagari et al. (2011) emphasized the question of which role the different characteristics of digital technologies play in terms of technostress. The characteristics of digital technologies refer to the functional and non-functional features perceived by the user, which can be pursued directly or indirectly. Many other researchers followed the call of Ayyagari et al. (2011) that their list of proposed characteristics might not be exhaustive and that the introduction of new technologies in the future might also result in new characteristics. Therefore, Maier et al. (2015) analyzed characteristics of enterprise resource planning (ERP) systems, Salo et al. (2019) focused on characteristics of social network services, and Hung et al. (2015) regarded mobile phone characteristics influencing technostress. In summary, there exist additional characteristics resulting from further research focusing on specific technologies or contexts that extend the list of Ayyagari et al. (2011) . However, to eliminate the black box phenomenon between technologies and technostress, further research is needed. Currently, there is no research that uses the extended list of characteristics to analyze their influence on technostress and no review of whether there are also other characteristics beyond that.

Furthermore, Ayyagari et al. (2011) analyzed the influence of technology characteristics on technostress by incorporating all digital technologies that are used at the workplace of their respondents without referring to a specific technology. Therefore, it is not ensured that respondents only think about one digital technology they use at work when answering the questionnaire. Instead, it is conceivable that the respondents mix their perception of using many different digital technologies, maybe even with those they use at home. This is also one of the significant drawbacks that Ayyagari et al. (2011) mentioned by themselves in their limitations section. However, analyzing the relation between the characteristics of one specific technology and technostress might seem to be by far more precise and concrete, as it does not mix-up and allow for bias when participants have different technologies in mind. On the other side, it does not properly reflect reality. Typically, people use a combination, and hence, the assessment of technostress incorporates the experiences with multiple digital technologies and not only with a specific technology. However, there are no considerations to assess the characteristics of specific digital technologies building digital technology profiles in order to summarize these across all technologies used at the user's workplace to explain the connection with technostress. Research on the design of digital workplaces examined people-focused and process-focused design approaches, in which information exchange and sharing documents or project support was regarded, without the impact on technostress (Williams & Schubert, 2018). Therefore, an understanding of characteristics of digital technologies, their interplay at the workplace, and how they influence technostress will be valuable as it can assist developers of digital technologies and designers of workplaces in a way that can prevent technostress.

Therefore, we aim to add to technostress literature by addressing the following three research questions (RQ):

RQ1) Which characteristics of digital technologies with relation to technostress exist?

RQ2) How does the characteristic profile of specific digital technologies look like?

RQ3) What is the influence of characteristic profiles of digital technologies used at the workplace on technostress?

In order to answer our research questions, we apply mixed methods. First, we conceptualize the relevant characteristics of digital technologies based on extant literature and qualitative research. Next, to be able to evaluate the characteristics quantitatively, we collect existing items scales, develop new multi-item scales where necessary, and perform an initial reliability and validity test of our scales via card-sorting and a quantitative pre-test. Then, we further validate the scales in a large-scale survey with both exploratory (EFA) and confirmatory factor analyses (CFA). Based on survey data, we develop characteristic profiles of multiple specific technologies used at the respondent’s workplace and determine their influence on technostress using structural equation modeling (SEM).

Our paper is structured as follows: Section 2 introduces the theoretical background, including the characteristics of digital technologies that have already been found to influence technostress. Section 3 presents the methodology, while section 4 describes the development of the digital technology profiles based on interviews with experts and focus groups as well as a survey with 4,560 users of digital technologies in different organizations. Section 5 analyzes the relationship between the developed digital technology profiles of specific technologies with technostress. Finally, section 6 discusses these results and concludes the paper.

1.2. Theoretical Background and Related Work

Digital workplaces are characterized by the set of digital technologies provided to execute one's work effectively, irrespective of the location, and whether the task is performed alone or with others (Williams & Schubert, 2018). Bharadwaj et al. (2013, p. 471) defines digital technologies as “combinations of information, computing, communication, and connectivity technologies” and refer to the importance of the interplay of digital technologies. Digital technologies include social, mobile, analytics, and cloud technologies, as well as the internet of things, and are known by the SMACIT acronym (Sebastian et al., 2017). Vial (2019) also includes platforms, the internet, software, and blockchain to the term of digital technologies, whereas only platforms are mentioned frequently in research articles (Tan et al., 2015; Tiwana et al., 2010). Elements of a digital workplace include digital technologies accessible by every stakeholder and interaction is possible without any physical limitations (Dahlan et al.). The objective of digital workplaces is to improve collaboration and communication in the organization and has gained relevance in the past years (Yalina, 2019). The design of a digital workplace is crucial for the worker’s productivity, especially for knowledge workers (Köffer, 2015; Yalina, 2019). People-focused and process-focused design principles exist, dealing with information exchange and project support issues (Williams & Schubert, 2018). Dery et al. (2017) illustrated how one can successfully design digital workplaces to drive organizational success. They mention that positive employee experiences of collaborating with others and dealing with the complexity of digital workplaces enable innovation and name possible improvements for the digital workplace, including fast log-in and mobility, but do not consider the possible effects on the individuals well-being.

Besides the positive effects of the use of digital technologies including an increase in productivity, effectiveness, and efficiency (Bharadwaj, 2000; Melville et al., 2004), research has shown the potential of digital technologies to cause technostress, as a specific form of stress that is perceived by end-users of digital technologies (Brod, 1984; Ragu-Nathan et al., 2008). Technostress is not created by the technology itself but emerges from the interaction of human users with digital technologies. Whether technostress emerges depends on the user's resources, capabilities, assessments, and the type of technology (Gimpel et al., 2019). Ayyagari et al. (2011) developed a technostress framework consisting of the main concepts of stress (technostress creators and strains) and the IT artifact consisting of technology characteristics (see Figure 1). Following this framework, a user's perception of features and attributes of a digital technology (technology characteristics) can lead to stress-creating stimuli which again create responses and outcomes for the user (strains) (Ayyagari et al., 2011; Salo et al., 2019).

Figure 1. Technostress Framework by Ayyagari et al. (2011).

Digital technologies can be characterized in different ways depending on the point of view, e.g., along with their physical components, approaches, and concepts (Berger et al., 2018). Concerning the link of digital technologies with technostress, prior research analyzed characteristics of single digital technologies (Hung et al., 2015; Salo et al., 2019; Westermann et al., 2015) or digital technologies in general (Ayyagari et al., 2011; Tarafdar et al., 2007). Analyzing social networking services as one digital technology, Salo et al. (2019) found two main characteristics: (1) self-disclose features regarding information about oneself and (2) information cue paucity referring to the limited, one-sided information delivery. Hung et al. (2015) characterized mobile technologies by high accessibility, mobility, ubiquity, and connectivity. Additionally, Westermann et al. (2015) found that push notifications are often assessed to be disturbing, which can also be seen as a characteristic. Ayyagari et al. (2011) defined characteristics of digital technologies in general based on how individuals perceive them in use. Ayyagari et al. (2011) found six characteristics categorized in usability, dynamic, and intrusive features. Usability features are usefulness, complexity, and reliability. The single dynamic feature is the pace of change. Intrusive features are presenteeism and anonymity. Adding to these six characteristics, Tarafdar et al. (2019) mention mobility.

Regarding technostress creators, Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) developed and empirically validated scales for five factors, which create technostress among individuals. The first dimension is techno-overload, describing situations where greater workload and higher speed are caused by digital technologies. Secondly, techno-invasion describes the effect of being constantly reachable and connected, leading to a blurring boundary between work and private life. The third creator is called techno-complexity, which describes the feeling of not having the needed skills and experiences to deal with the complexity of digital technologies and being forced to spend time and effort in learning it. Techno-insecurity describes the fear of losing one’s jobs due to automation or missing skills to deal with digital technologies. Lastly, techno-uncertainty refers to the feeling of having to constantly develop one’s abilities and knowledge due to continuing technology changes and upgrades.

Prior research has also pointed out the outcomes of technostress. The most recorded strain is the negative effect on end-user satisfaction, followed by job satisfaction, performance, productivity, and organizational commitment (Sarabadani et al., 2018). Tarafdar et al. (2007) stated that higher technostress results in lower productivity. Ragu-Nathan et al. (2008) showed that technostress creators decrease job satisfaction as well as organizational and continuance commitment. Both are emphasized by Tu et al. (2005), who found that next to lower productivity, also higher employee turnover can result out of technostress. Concerning individuals' health, Mahapatra and Pati (2018) found that, in an Indian context, techno-invasion and techno-insecurity can lead to burnout which, in turn, is associated with several negative outcomes on the organizational and individual level including lower productivity, job satisfaction, and higher absenteeism as well as depression and anxiety (Maslach et al., 2001). For German employees, Gimpel, Lanzl, et al. (2018) found that higher levels of technostress go along with a higher number of people reporting to suffer from headaches, fatigue, sleeping problems, and exhaustion, for example.

1.3. Research Process

As we strive to answer three interconnected questions, our research process is divided into three parts, each of them applying a combination of various methods. We conduct a mixed-methods approach, as described by Venkatesh et al. (2013). It includes and integrates qualitative as well as quantitative investigations, which, according to Venkatesh et al.'s (2013) scheme, serve developmental purposes.

First of all, we aim to identify the characteristics of digital technologies that relate to technostress. For identifying and conceptualizing the characteristics of digital technologies, we follow steps one to six of the process of MacKenzie et al. (2011) . We conduct a literature research and interviews with experts and focus groups. Based on this, we develop multi-item survey scales for the characteristics of specific digital technologies. The scales and individual items are refined based on results from card-sorting regarding their content and face validity. Next, we perform a pre-test and an exploratory factor analysis (EFA) and, again, refine the scales and individual items.

Second, the resulting scales are then used in a large-scale quantitative survey. For the validation, the data is split into two random subsets. On the first subset, an additional EFA is carried out to examine the revised items. Finally, a confirmatory factor analysis (CFA) is performed on the second subset to validate the scales. Furthermore, we used the data to calculate a normed characteristics profile for specific technologies by aggregating the answers across many respondents.

Third, as we argue that technostress does not solely depend on the usage of a single technology but on the combination of all technologies used at the workplace, we, hence, use in the further course the digital technology profiles of the used technologies at the respondents' workplace. Therefore, we use covariance-based structural equation modeling (SEM) to estimate the effect on technostress.

1.4. The Development of Digital Technology Profiles

1.4.1. Theoretical Conceptualization

In order to build the foundation for our research, in a first step, we conducted a literature search. The focus was to identify technologies and their characteristics in relation to technostress (creators). To cover the full picture, the search additionally comprised literature of linked outcomes like stress and strain (including health and well-being). The list covered a broad picture of literature in different areas. Databases, namely EBSCO Business Source Premier, EBSCO Academic Search Premier, EBSCO Psych, Web of Science, and PubMed, were searched in the languages English and German. Because the seminal paper by Tarafdar et al. was published in 2007, only publications from this year onwards were included. The list of search strings is available in Supplemental Material A[4]. Types of publications that were

[4] https://bit.ly/3aVPAdn

considered are (academic) journals, reviews, proceedings, books, book chapters, and dissertations. Overall, 273 articles relevant for our research were identified.

To enrich the insights from the literature research, we interviewed practitioners and experts. The semi-structured interview guideline included questions about technostress creators, technologies for which usage may cause stress, and technology characteristics, which the subjects believed to cause stress and stressful usage behaviors. The complete interview guideline can be found in Supplemental Material B. In total, 15 people participated in face-to-face interviews, including employee and employer representatives, experts from occupational health management, ethics, ergonomics, informatics, and human resource management. Each interview lasted between 30 and 90 minutes. The number of interviews was determined by content saturation, meaning interviews were conducted until no new aspects were identified and named by our experts. Interviews were audio-recorded, transcribed, and continuously analyzed through MAXQDA with a formalized coding strategy. Categories were built deductively because the interviews were structured in sections with questions concerning technologies, their characteristics, and how these exactly relate to technostress. These particular aspects guided the analysis to gain a better understanding of the relationship.

Following on from this, six focus groups were conducted (between 5 and 8 participants each) consisting of employees and managers from four different organizations (n = 33). The groups covered different occupational groups and hierarchies. Participants were contacted by a responsible from the respective company and were asked to take part voluntarily. The groups almost got identical task descriptions to the experts. First, they named the technologies they use at the workplace and their characteristics. They rated which of these caused the most stress. Besides, they were asked for (short-term and long-term) consequences and successful strategies to cope with the stress. The guideline for the focus group workshop is available in Supplemental Material C. The aim was to get insights from the practical perspective and collect examples for aspects that were named by our experts. All group discussions were recorded by an observer and the results documented in a picture protocol. Again, the results were written down, coded, and aggregated. For the technologies, for example, categories were identified when they named one specific software product (e.g., Edge as an example for an Internet browser).

The result of these steps is a conceptual understanding of nine characteristics of digital technologies relating to technostress. See Table 1 for their definition.

Table 1. Characteristics of Digital Technologies, their Source, and Definition.

Characteristic	**Definition**
Anonymity	Degree to which the use of a digital technology stays anonymous and cannot be identified by others (in accordance with Ayyagari et al. (2011)).
Intangibility of Results	Degree to which results of the work with a digital technology are immaterial in nature and therefore intangible (self-developed).
Mobility	Degree to which a digital technology is usable independent of the location and enables to work from almost anywhere (self-developed).
Pace of Change	Degree to which a digital technology changes dynamically and rapidly (in accordance with Ayyagari et al. (2011)).
Pull[5]	Degree to which information of a digital technology is provided only on request (self-developed).
Push[3]	Degree to which a digital technology automatically provides new information while using it (in accordance with Westermann et al. (2015)).
Reachability	Degree to which a digital technology enables the individual to be contacted by third parties (in accordance with presenteeism in Ayyagari et al. (2011)).
Reliability	Degree to which a digital technology works reliably and is free of errors and crashes (in accordance with Ayyagari et al. (2011)).
Simplicity of Use	Degree to which a digital technology can be used without major effort or training (in accordance with complexity in Ayyagari et al. (2011)).
Usefulness	Degree to which a digital technology supports the accomplishment of tasks and enhances job performance (in accordance with Ayyagari et al. (2011)).

[5] Please note that pull and push were first conceptualized as one characteristic with pull and push at opposite ends of the continuum. It was revised in later steps. Notifications may, only in some cases for some features, be configured by the user for certain technologies. Hence, individual settings of the users were not considered, and items were phrased with a general wording.

Please note that in a later quantitative pre-test, one characteristic (information provision) was split into two (push and pull). For brevity of presentation, Table 1 already shows this split. Simplicity of use refers to the characteristic complexity by Ayyagari et al. (2011). It was renamed to avoid confusion with the technostress creator techno-complexity (Ragu-Nathan et al., 2008). Reachability refers to the characteristic presenteeism by Ayyagari et al. (2011) and was renamed to avoid confusion with a common psychological phenomenon describing the feeling of obligation by employees to go to work even though they are ill.

To sum up, we identified characteristics of digital technologies that — according to literature and qualitative empirical research — relate to technostress. This answers RQ1.

1.4.2. Operationalization and Evaluation of Characteristics

For the development of scales for the characteristics of digital technologies, we followed the guidelines of MacKenzie et al. (2011). Based on this, we collected items for already existing characteristics and further created items for newly identified characteristics resulting in the first draft of our scales. We created our items to be short and simple and use appropriate language for employees. During the development, we carefully made sure that the items only address one single aspect (i.e., no connection of different statements in one item) in order to prevent a confusion of the respondent. Thereby, we also considered recommendations proposed by Podsakoff et al. (2003) to avoid common method bias by "improving scale items" (Podsakoff et al., 2003, p. 888). We used the anchor points of the existing rating scales to retain the interpretability and comparability of the results with the existing studies.

To evaluate content validity, we conducted a card-sorting via an online matching task with fellow researchers (n=39) in which they were asked to map items to characteristics (definition of the constructs) (Moore & Benbasat, 1991). 85% correct matches were defined as the minimum boundary for the retainment of an item. Out of the 26 items, 22 were mapped correctly to the related construct by more than 85% of the persons, so we did not change them. The remaining four items were matched correctly by less than 85% of the participants. Thus, we changed the wording of these items to fit the corresponding construct better, provide more clarity, and reduce ambiguity. This step of item generation finished with the revised scales.

To evaluate the structure of our scales and validate our reworked items, we conducted a pre-test. 445 respondents who were acquired via an online panel took part in the study. The data was collected anonymously as far as possible (some socio-demographic questions were included to evaluate the quality of the intended sample). Participants were instructed to respond honestly and gave informed consent to participation. This was done to further minimize common-method bias by "protecting respondent anonymity and reducing evaluation apprehension" (Podsakoff et al., 2003, p. 888). This principle was applied to all data collection processes. To get a better understanding of the participant's digital workplace, each respondent of our survey stated his or her usage of 40 technologies (Nüske et al., 2019), evaluated by 0 = "no usage", 1 = "monthly usage", 2 = "weekly usage", 3 = "daily usage", and 4 = "several times a day". The list of technologies included common hardware used at the workplace like a printer, laptop or stationary phone, software like text, table, and presentation programs, simulation programs, statistical and analysis tools, networks like cloud systems, intranet, wifi, and technologies like virtual augmented reality and mixed reality. Participants evaluated their perception regarding the characteristics of one randomly selected technology that they used at least weekly. We decided to give each participant only one technology to reduce dropouts due to the length of the survey.

We performed an EFA (parallel analysis revealed nine factors that were extracted using principal axis factoring with an oblimin rotation) to carefully assess the quality of our questionnaire and did a preliminary analysis of all scales. The result of this EFA properly reflected our assumption of the factor structure of the scales with nine underlying technology characteristics. However, we faced some problems. First of all, we observed a few severe cross-loadings between the constructs simplicity of use and reliability. Also, we originally derived a bipolar construct “information provision” that contained aspects about how digital technologies provide users with information distinguishing whether the information has to be requested explicitly by the user (pull) or whether they are provided automatically when available (push). Regarding the issues with the properties of the items of this characteristic, we decided to redefine it and created two separate scales for push and pull as they seem to be more than two ends of one construct. The two scales refer to the original settings of the technologies. Items were phrased with a general wording, that did not consider the individual settings of the user. In some cases, of course, it is possible to adjust the individual settings (e.g., turn off notifications on the lock screen of the smartphone) but this does not apply to all devices and features. In addition, organizational policies possibly interact with personal preferences (e.g., a user may be able to set his stationary telephone on mute, but he does not use this option because the supervisor expects him/her to be reachable on the phone for customers). Finally, we revised the items accordingly.

To go on in our evaluation and validation process, we conducted a large-scale study distributing a questionnaire that, among other things, contained our scales on characteristics of digital technologies. These were assessed with the same procedure as in the pre-test: each participant rated the characteristics of one randomly drawn technology from the list of 40, which (s)he uses. To evaluate the respondent's technostress level, the items belonging to the five technostress creators introduced by Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) , namely techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty were included in the survey. This served the last step of our research to test for the influence of technology profiles on technostress. We acquired respondents for the surveys via an external research panel focusing on German employees. Respondents were paid for participation in the study. We included control variables to review the representability of our sample. These comprised gender, employment status, occupational title and sector, number of hours worked per week, and education. The sample for the evaluation consisted of 4,560 respondents. The distribution of participants was representative of the German working population with respect to the control variables age, gender, and occupational sector.

We used a five-point Likert-type rating scale from 0 = “I do not agree at all” to 4 = “I totally agree” to measure the technostress creators as well as the characteristics of digital technologies. All questions were presented in German. If necessary, the items were translated. Therefore, multiple German native speakers translated the questions in parallel. They met afterward to resolve discrepancies and agree on the most suiting translation. For more detailed information about the final scales used in this study and their sources, see Table 6 in the Appendix. For a list of the technologies, see Supplemental Material D.

As the EFA in the pre-test showed few severe cross-loadings between some constructs, we reinvestigated the factor structure with an EFA in the data set of the main study. Therefore, we split our study population into two evenly large subsets. On the first subset (n=2,280), we performed the EFA (parallel analysis revealed ten factors that were extracted using principal axis factoring with an oblimin rotation). This time no problematic cross-loadings of the items on a competing construct were observed. For more detailed information on the results of this EFA see Supplemental Material E. Following the EFA, we performed a CFA on the second subset (n=2,280) with maximum likelihood estimation of fifteen latent factors (ten characteristics of digital technologies, five technostress creators) that were allowed to intercorrelate in the model to analyze our measurement model further. The descriptive statistics, item reliabilities, and internal consistency are presented in Table 2.

Table 2. Statistical Quality of the Measures Used in the Study: Descriptive Statistics, Item Reliabilities, Internal Consistency, and AVE.

Construct	No. of Items	Mean	Standard Deviation	Loadings	Cronbach's α	AVE
Anonymity	4	1.78	1.10	0.76-0.92	0.89	0.82
Intangibility of Results	6	1.58	1.10	0.60-0.90	0.92	0.80
Mobility	5	2.55	1.27	0.76-0.93	0.93	0.85
Pace of Change	4	1.78	1.15	0.92-0.94	0.96	0.93
Pull	3	2.47	1.00	0.74-0.89	0.83	0.80
Push	3	2.07	1.17	0.75-0.85	0.85	0.81
Reachability	4	2.71	1.24	0.92-0.95	0.97	0.94
Reliability	3	2.92	0.89	0.86-0.93	0.93	0.90
Simplicity of Use	3	3.13	0.89	0.81-0.92	0.90	0.87
Usefulness	4	2.81	1.05	0.82-0.90	0.92	0.86
Techno-Complexity	5	1.23	1.23	0.81-0.88	0.90	0.71
Techno-Insecurity	4	1.24	1.29	0.78-0.86	0.83	0.66
Techno-Invasion	3	1.28	1.35	0.75-0.90	0.80	0.72
Techno-Overload	4	1.63	1.30	0.79-0.90	0.88	0.74
Techno-Uncertainty	4	1.81	1.23	0.81-0.88	0.87	0.72

All loadings of the items on their respective latent factors in the CFA were above the value of 0.71, which indicates that more than 50 % of the variance of this item is explained by the underlying construct. Only for the intangibility of results, lower loadings were observed. However, since the average variance extracted (AVE) of intangibility of results (and for all other constructs) was above 0.50, we did not consider it critical and retained the indicators. Cronbach's Alpha showed values of at least 0.80 for all scales indicating internal consistency.

In the next step, we assessed discriminant validity based on the Fornell-Larcker criterion (Fornell & Larcker, 1981) as Cronbach's Alpha relies on correlations of the items and, thus, does not account for dimensionality of constructs. The Fornell-Larcker criterion compares the size of the correlations of the latent constructs to the AVE. The square root of each construct's AVE was higher than the correlations with the other constructs (see Table 6 in Supplemental

Material F). Another, newer criterion to asses discriminant validity is the heterotrait-monotrait ratio introduced by Henseler et al. (2015). It sets the average correlation of items measuring different constructs (heterotrait-heteromethod) in relation to the average correlations of items measuring the same construct (monotrait-heteromethod). If the indicators of one construct correlate higher with each other than with the indicators of different constructs, the ratios should be small. Ratios close to 1 indicate a lack of discriminant validity. The ratios were obtained for the characteristics of digital technologies and the technostress creators as they are used in the model to analyze for our second research question. All ratios were below 0.85, indicating that discriminant validity is good. For more detailed information on the results, see Table 7 in Supplemental Material F. Overall, we consider discriminant validity as given.

In the last step of validating our measurement instrument, we evaluated the fit of our model to gain further information about our assumptions on the data structure. The fit was judged according to the following guidelines: The root mean square error of approximation (RMSEA) indicates good model fit at values smaller than 0.6. The square root mean residual (SRMR) should show values smaller than 0.05. Comparative fit index (CFI) and Tucker-Lewis index (TLI) indicate a satisfactory model fit if they are higher than 0.90 and good fit at values above 0.95. We did not consider chi-square for the evaluation of the model fit, because the indicator has shown to be sensible to sample size in simulation studies (Boomsma, 1982). For our model, CFI (0.956) and TLI (0.951) were above 0.95, indicating good fit of the initial model with ten latent, correlating characteristics. Both SRMR (0.036) and RMSEA (0.044) showed only small deviations of the estimated from the expected covariance matrix with values below 0.05 and/or 0.06, respectively. Therefore, we argue that we finally validated our measurement model. To sum up, we now have validated measurement scales for the identified characteristics of digital technologies that — according to literature and qualitative empirical research — relate to technostress.

To confirm this ten-factor structure, a nested model comparison was conducted. The simpler model comprised nine latent factors (interim result from the first EFA in pre-test, reapplied to data from the main study) where all items of the two factors simplicity of use and reliability loaded on the same, common construct. A chi-square difference test revealed significant better fit (χ^2_{Model1} = 5277.18, χ^2_{Model2} = 3327.98, df_{Model1} = 651, df_{Model2} = 657, $\Delta\chi^2$ = -1949.20) of the model with ten latent factors. The fit indices are displayed in Table 3.

Table 3. Nested-Model Comparison of the Measurement Model for the Technology Characteristics.

Model	CFI	TLI	RMSEA	SRMR
Nine Factors – Model 1	0.924	0.914	0.059	0.041
Ten Factors – Model 2	0.956	0.951	0.044	0.036

1.4.3. Profiles of Digital Technologies based on their Characteristics.

To get a better understanding of the differences between technologies with respect to their characteristics, we created a profile for each of the 40 digital technologies from our list. Each profile line consists of the means of all ten characteristics that were evaluated for this one specific technology. We argue that the characteristic of a digital technology that is used more frequently has a higher impact on the overall perceived characteristics of digital technologies. Therefore, we only regarded the responses of persons that used this specific technology at least once a day. We then calculated a mean score for the ten characteristics. See Table 4 for examples.

From the overall list of 40 technologies, some had to be excluded for the profiles. Due to the randomized choice which technology the respondent was asked to evaluate, group sizes were in some cases below 30. These were considered too small to provide unbiased information. For example, 86 used augmented, virtual and mixed reality daily, but only ten respondents were asked to evaluate its characteristics due to the randomized sampling. All profiles with means and standard deviations are provided in Table 4. The table shows how different technologies are perceived by users. It is important to note that these perceptions are from users, that is, they are conditional on the respondent working in a job where the employer assumes a task-technology fit and, thus, provides the technology. Cash systems have a higher perceived usefulness than statistics software to pick just one example. Likely, only few people use both types of systems. The perceptions originate from different people in different jobs. Five profiles are visually displayed in Figure 2 to highlight similarities and differences. For example, smartphones enable mobile working represented by high values of mobility. The same applies to e-mails because usually, these can be checked on the run with the smartphone. However, in contrast to smartphones, e-mails have a rather low pace of change. A new smartphone is released almost every other week by different companies, whereas the functionality of the e-mail program remains the same as ten years ago (Figure 2).

To sum up, we now have profiles of the 26 most important (i.e., common and frequently used) workplace technologies along with the characteristics that — according to literature and qualitative empirical research — relate to technostress. This answers RQ2.

Table 4. Profiles of Digital Technologies: Mean and Standard Deviation for each Characteristic.

Technology	n	Usefulness		Simplicity of Use		Reliability		Anonymity		Mobility		Reachability		Pace of Change		Pull		Push		Intangibility	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Administrative Software	69	3.02	0.98	2.79	1.00	2.82	0.89	1.50	1.15	2.18	1.39	2.19	1.34	1.90	1.01	2.47	1.20	1.71	1.15	1.38	1.13
Cash System	41	3.08	1.10	3.49	0.73	3.19	0.73	1.80	1.39	2.14	1.68	1.37	1.57	1.53	1.38	2.46	1.37	1.69	1.53	1.64	1.50
Cloud Computing	54	2.60	1.04	2.73	1.01	2.44	1.03	1.64	1.13	2.88	1.16	2.53	1.25	2.16	0.96	2.49	1.16	1.97	1.22	1.66	1.17
Database	134	2.86	1.05	2.60	1.04	2.71	0.96	1.61	1.16	2.15	1.37	1.92	1.32	1.88	1.09	2.44	1.18	1.92	1.29	1.46	1.22
E-Mail	311	3.10	1.07	3.68	0.68	3.41	0.72	1.50	1.27	3.31	1.21	3.70	0.62	1.15	1.14	2.45	1.31	2.38	1.38	1.57	1.32
Headset	69	2.89	1.17	3.35	0.98	3.16	1.00	1.78	1.45	2.32	1.48	2.97	1.18	1.18	1.28	1.75	1.41	1.69	1.39	1.83	1.35
Internet	220	3.10	0.97	3.42	0.76	2.88	0.84	1.86	1.22	3.25	1.06	3.22	0.95	2.10	1.07	2.61	1.10	2.10	1.20	1.65	1.12
Knowledge Management	91	2.86	1.07	2.92	1.05	2.70	1.00	1.91	1.28	2.55	1.33	2.36	1.25	2.21	1.08	2.54	1.12	1.86	1.22	1.68	1.19
Laptop	125	3.07	1.15	3.55	0.74	3.29	0.78	1.79	1.28	3.23	1.15	3.03	1.07	1.73	1.18	2.65	1.10	2.06	1.30	1.23	1.23
Logistics System	33	3.05	0.91	2.94	0.95	2.65	1.00	1.92	1.23	1.96	1.45	1.86	1.42	2.04	1.28	2.60	1.09	1.99	1.31	1.45	1.33
Management Information Software	42	2.66	0.99	2.60	0.88	2.62	0.89	1.69	1.36	2.53	1.25	2.53	1.29	2.40	1.06	2.64	1.12	1.91	1.38	1.65	1.40
Mobile Phone	62	2.35	1.37	3.46	0.97	2.98	1.18	1.75	1.35	2.79	1.46	3.54	0.80	1.15	1.20	2.23	1.24	1.88	1.39	2.10	1.13
Network Hardware	82	2.78	1.07	2.69	0.95	2.56	0.94	1.58	1.16	2.55	1.29	3.01	1.03	2.07	1.07	2.35	1.12	1.93	1.26	1.58	1.13
Office Software	188	3.33	0.85	3.09	0.91	3.12	0.86	1.95	1.21	2.98	1.22	1.83	1.37	1.64	1.15	2.13	1.23	1.45	1.30	1.21	1.27
PC	301	3.17	1.04	3.27	0.85	3.01	0.85	1.51	1.23	1.48	1.52	2.92	1.13	1.80	1.20	2.64	1.10	1.98	1.32	1.33	1.20
Printer	303	3.25	0.96	3.57	0.70	3.24	0.82	1.74	1.35	1.87	1.57	2.39	1.47	1.27	1.19	2.20	1.34	1.72	1.44	1.07	1.21
Production Planning	30	2.77	1.14	2.46	0.98	2.46	1.09	1.75	1.26	1.91	1.43	1.73	1.30	1.70	1.28	2.34	1.30	1.71	1.37	1.81	1.24
Realtime Communication	50	2.89	1.11	3.19	1.00	2.84	1.08	1.81	1.38	2.68	1.44	3.22	0.89	2.05	1.15	2.46	1.16	2.41	1.30	1.94	1.18
Security background	94	2.18	1.28	2.55	1.02	2.79	0.94	2.00	1.11	2.93	1.18	2.13	1.27	1.94	1.19	2.39	1.16	2.12	1.24	2.08	1.27
Security Interaction	150	1.68	1.30	2.99	1.00	2.87	0.91	1.79	1.23	2.49	1.37	1.96	1.36	1.74	1.29	2.53	1.14	1.81	1.29	1.75	1.25
Smartphone	151	2.56	1.26	3.25	0.92	2.91	0.95	1.74	1.14	3.16	1.13	3.55	0.81	2.37	1.08	2.56	1.15	2.32	1.26	1.78	1.24
Social Collaboration	71	2.46	1.14	2.77	0.92	2.27	1.00	1.63	1.12	2.93	1.09	3.19	0.87	2.19	0.99	2.38	1.05	2.32	1.15	2.03	1.06
Statistics Software	32	2.85	0.96	2.58	0.99	2.77	1.00	2.36	1.23	2.44	1.32	2.29	1.35	2.26	1.08	2.37	0.98	1.99	1.29	1.72	1.42
Tablet	58	2.68	1.29	3.47	0.87	2.81	1.14	1.73	1.25	3.09	1.21	2.76	1.32	1.83	1.27	2.64	1.24	2.15	1.40	1.69	1.40
Telephone	246	2.79	1.14	3.60	0.75	3.42	0.81	1.48	1.40	1.23	1.53	3.50	0.82	0.83	1.16	2.15	1.38	1.64	1.45	1.90	1.37
Wireless Network	164	2.94	1.13	3.21	0.90	2.74	0.92	1.91	1.22	2.85	1.23	3.34	0.85	2.01	1.17	2.49	1.17	2.29	1.23	1.64	1.26

Note. We do not provide a characteristics profile for content management systems, creative- and design-software, medical software, augmented, virtual and mixed reality, digital cash flows systems, sensory systems, artificial intelligence, automatic productions systems, e-commerce systems, product/software development tools, voice interaction technologies, systems for localization and distance determination, and simulation/ modelling software ($n < 30$).

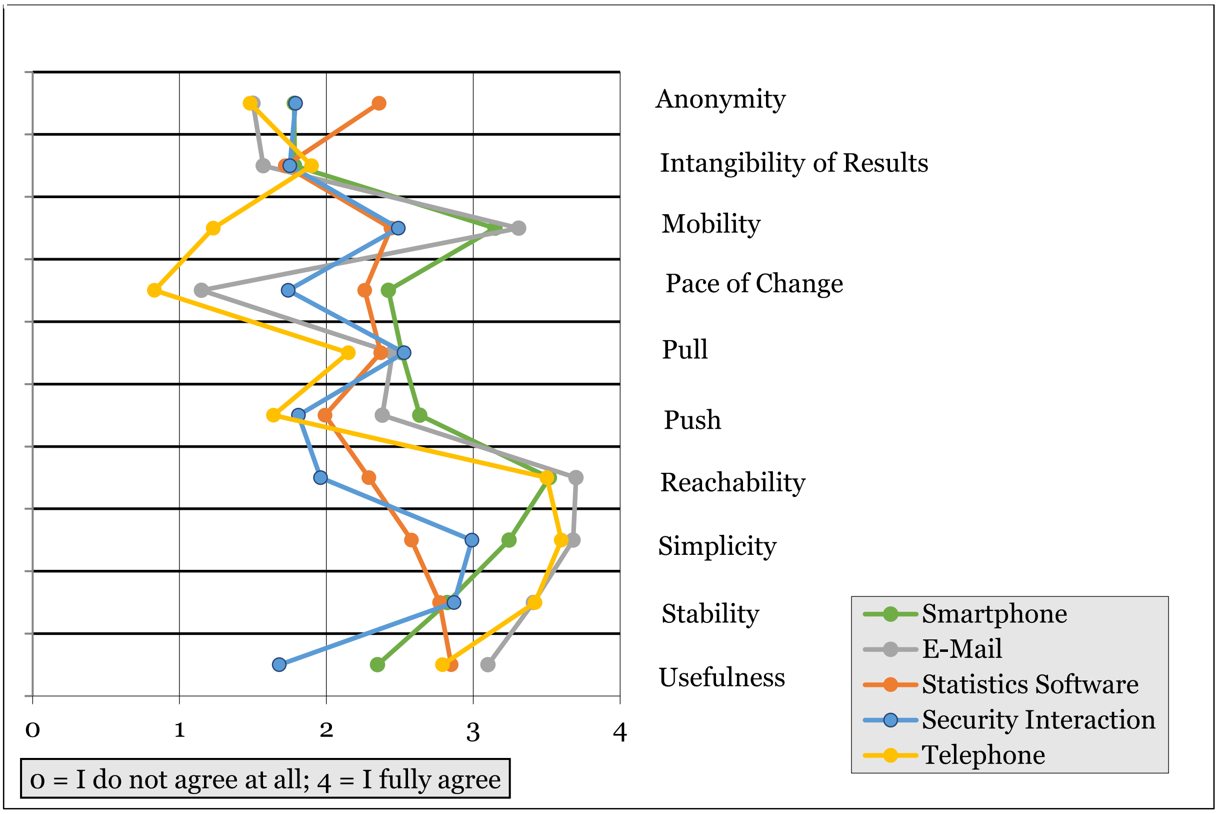

Figure 2. Profiles of Five Different Digital Technologies Based on their Characteristics.

1.5. The Influence of Technology Profiles on Technostress

Technostress at work arises from a workers' interaction with typically a range of digital technologies. It does not depend on a single digital technology but on the portfolio of digital technologies at the workplace and their characteristics profiles. Thus, in order to investigate the influence of technology profiles on technostress, we aggregated the profiles of the digital technologies to digital workplace portfolios. For example, for a respondent who uses a smartphone, laptop, e-mails, social collaboration software, and wireless networks for work, we took the characteristic profiles of these five digital technologies and averaged them to build one mean "portfolio" score across the five digital technologies for each of the ten characteristics.

We set up a covariance-based structural equation model (SEM) to measure the influence of the ten characteristics of the digital technology portfolio at the workplace on the five technostress creators techno-overload, techno-invasion, techno-complexity, techno-insecurity, and techno-uncertainty (Ragu-Nathan et al., 2008; Tarafdar et al., 2007). We conducted Harman's single factor test, which showed that about 11 % is the highest proportion of variance attributed to one factor, which suggests that common-method bias is not a problem. Next, we statistically controlled for common-method bias by modeling a method factor (Podsakoff et al., 2003). The comparison of the results of the structural model with and without method factor showed no substantial differences (ΔCFI = 0,029). Researchers (Cheung & Rensvold, 2002; Little, 1997) have suggested that differences in the CFI less than .05 are acceptable and indicate the equivalence of measurement models. Thus, common-method bias seems not to be a major concern for our data. The model showed good fit to the data (CFI = 0.972, TLI = 0.962, SRMR = 0.031, RMSEA = 0.036).

Hypotheses were tested two-tailed because we did not have specific directional hypotheses about the influence of the characteristics of the digital workplace on technostress. Table 5 displays the results. For a detailed list of all paths and their respective t-statistics, including the p-values see Supplemental Material G.

Table 5. Digital Workplace Portfolio: The Influence of the Characteristic Profiles of Digital Technologies on the Five Technostress Creators.

TS Creator / Characteristic	Techno-Complexity	Techno-Insecurity	Techno-Invasion	Techno-Overload	Techno-Uncertainty
Anonymity	-0.16**	-0.27**	-0.40***	-0.10	-0.17
Intangibility of Results	+0.16**	+0.34***	+0.31***	+0.25***	+0.30***
Mobility	+0.08	+0.18***	+0.28***	+0.12**	+0.14**
Pace of Change	-0.04	+0.04	+0.31***	+0.10	+0.07
Pull	-0.16	-0.18	-0.40**	-0.23	-0.17
Push	+0.11	-0.08	-0.28**	-0.14	+0.03
Reachability	-0.20*	-0.16	-0.18*	-0.13	-0.17*
Reliability	-0.18	-0.25	-0.46**	-0.07	+0.11
Simplicity	+0.08	-0.19	+0.40*	-0.18	-0.50**
Usefulness	+0.00	+0.22**	+ 0.14	+0.11	+0.07
R^2	0.11	0.20	0.22	0.12	0.16

Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; '+' indicates that a higher value of the characteristic within the digital workplace portfolio is associated with a higher level of the technostress creator and '-' is vice versa.

In this final step of the analysis, we answer RQ3, which asked how the profiles of digital technologies used at the workplace influence technostress. Results of the structural model reveal that not all portfolios of characteristics at the digital workplace influence technostress in the same manner, but each of the characteristics is significantly linked to at least one technostress creator.

1.6. Discussion and Conclusion

We investigated the characteristics of digital technologies that are related to technostress. Therefore, we did a literature search and qualitative interviews in order to expand the understanding of characteristics that have previously been presented in the literature. To validate the characteristics as well as their relationship with technostress, we conducted a quantitative survey study. We used structural equation modelling to reveal the characteristics' relationship with technostress creators. The results answer our three research questions by showing the existence of ten characteristics of digital technologies related to technostress, profiling 26 common workplace technologies along the ten characteristics, and relating the digital workplace portfolio with technostress creators.

In terms of revealing characteristics of digital technologies with relation to technostress creators, we found evidence for ten different characteristics. Each technology characteristic relates to at least one technostress creator and each technostress creator to at least two characteristics.

In this dense web of relationships, we found that anonymity is negatively related to complexity, insecurity, and invasion. For insecurity, for example, this means that if the users may use their technologies anonymously without leaving traces of their usage behavior, employees fear to lose their jobs less as they less feel their work activities to be monitored. Intangibility of results is positively associated with all five technostress creators. Again, for insecurity, this relationship is understandable as employees experience more fear of losing their jobs if they do not see the results of their work and thereby feel no progress in accomplishing their tasks. Regarding these two results concerning insecurity in combination this could be interpreted in the following way: With high intangibility of results, employees might experience a lack of productivity and they fear losing their job because this seemingly poor performance could be controlled or traced, for example by the supervisor, if a system does not allow anonymous usage. For mobility, we found positive relations with insecurity, invasion, overload, and uncertainty. With regard to invasion, this may be because mobile workplaces allow individuals for more flexibility in doing their tasks. Therefore, they may experience a stronger feeling of blurring boundaries between job and private life, resulting in higher levels of perceived invasion. Pace of change is only related to invasion and the relationship is positive, meaning that a high pace of change increases the feeling of one's life being invaded with digital technologies. This may be because employees have to use their non-work times (e.g., weekends) in order to deal with the newly changed digital technologies and learn how to use them and, thus, feel their private lives as being invaded by digital technologies. In contrast to pace of change, pull as well as push is negatively linked with invasion. For pull, this relationship may be because individuals actively have to access information via their digital workplace portfolio and, thus, are more in control of when they want to do so. For push, however, in the first sense, one would expect a positive link to invasion. But we argue that, if individuals know that their digital technologies will notify the individuals about important work issues, they do not have to constantly check their smartphone or other digital technologies for important updates and, thus, can mentally disconnect from their job when being with their family. Reachability is negatively associated with complexity, invasion, and uncertainty. One possible interpretation of the decreasing uncertainty could be that people who are well reachable (i.e., due to their position) will inevitably interact and deal with the technology permanently, which means that they have little uncertainty in using it. For reliability, we only found a negative relation to invasion. Simplicity is linked with invasion and uncertainty. For invasion, the relation is positive, whereas, for uncertainty, it is negative. Interestingly, simplicity does not affect complexity. Lastly and unexpectedly, usefulness is positively related to insecurity. At this point, further research is needed to better understand and interpret the relationship.

Our paper contributes to theory in several ways. Our first contribution is the identification and definition of further characteristics of digital technologies that affect technostress at an individual's workplace, including measurement scales for the newly added characteristics. Placing these newly identified characteristics side by side with the ones from extant literature, (esp. from Ayyagari et al., 2011) our paper presents the most holistic set of technology characteristics related to technostress. Further, to the best of our knowledge, we are the first to combine the characteristics of Ayyagari et al. (2011) with the technostress creators of Ragu-Nathan et al. (2008) and thereby can show their relationships. With this broader understanding of characteristics, future research can investigate the influence of digitalization on technostress in more detail.

Second, we show that it is important to investigate the workplace as a whole based on the portfolio of technologies at the workplace. Prior research either investigates individual technologies (e.g., Hung et al., 2015; Maier et al., 2015; Salo et al., 2019) or the entire digital workplace without considering the individual technologies at work (e.g., Ragu-Nathan et al., 2008; Tarafdar et al., 2007). We take an intermediate way considering all major individual digital technologies at the workplace. We build technology profiles on the individuals' perception of characteristics and not by asking technology experts. Stress is a construct that builds on the perception of a situation and the individual's own ability to cope with a certain situation. Therefore, from the individual's point of view, the perceived characteristics of digital technologies at the workplace are key because stress is neither solely anchored in the environment and its demands nor solely in the person characteristics (Lazarus & Folkman, 1984). Asking users rather than design experts seems appropriate according to adaptive structuration theory (DeSanctis & Poole, 1994). Outcomes of the use of advanced information technology do not only depend on the structure of the technology but also the social interaction of the user with the technology (which can be different than intended by the designer also depending on the organizational practices and norms). These profiles were put together to an individual portfolio consisting the mean characteristics of the different technologies each employee uses at his/her own workplace. This provides a more holistic picture than looking at only a single technology; further, it allows to trace the effects on technostress back to characteristics and from there to individual technologies rather than considering technologies at the workplace as monolithic.

Third and last, we give evidence on the relationship of the characteristics with different technostress creators instead of technostress in general. This more detailed understanding can help future research to develop specific preventive measures and coping strategies for concrete technostress creators at concrete workplaces. In sum, the identification and measurement of characteristics of digital technologies along with knowledge on their effect on technostress enable future research to cluster technologies and evaluate different technologies and workplaces based on their impact on technostress. Future research could consider whether the technology profiles prove to be consistent among demographic and cultural differences. Also, the size of the technology profile combined with the intensity of usage or additional moderating characteristics influencing technostress can be analyzed.

The results of this study also provide implications for practice. Since prior research has shown the negative effects of technostress, including lower productivity and lower job satisfaction, organizations should aim to prevent and lower the level of technostress of their employees. Based on our developed items for characteristics of digital technologies, digital workplaces can be evaluated on their possible susceptibility to technostress, by for example identifying technologies that outshine the positive characteristics of other digital technologies in terms of technostress. This is important as we were able to show that the combination of technologies and their aggregated mean characteristics are associated with technostress creators. The combination of technologies matters as one technology with its' characteristics can distort the overall sensation and lead to technostress.

Workplace designers should focus on usability features, including usefulness, simplicity of use, and reliability, but also on technologies that enable mobility and pull configurations. When individual technostress creators are of specific concern for a given workplace or company, the guidance becomes more nuanced on which characteristics to look out for and which technologies have a favorable profile regarding these characteristics. Besides, individuals can affect their levels of technostress by adjusting their workplace technologies. Therefore, employers also should give their employees the flexibility of configuring their digital technologies in a way that is most beneficial for each individual.

However, there are limitations to our research. Each respondent to the survey assessed only the characteristics of one digital technology and not the characteristics of the digital technologies at her or his entire workplace. However, since our sample is of a high number, we were able to assign the perception of the characteristics between subjects.

Despite these limitations, our results add to a broader understanding of characteristics of digital technologies at an individual's workplace, not only by extending the number of characteristics that were already known but also by revealing the structure among them as well as their effect on technostress creators.

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1.9. Appendix

Table 6. Item Means, Standard Deviation and Factor Loadings of the Finale Scales Used in the Main Study (n = 4,560).

Construct	Item	Mean	*SD*	Est	Source
Usefulness	Use of {selected technology} enables me to accomplish tasks more quickly.	2.97	1.14	0.82	Ayyagari et al. (2011)
	Use of {selected technology} improves the quality of my work.	2.65	1.18	0.83	
	Use of {selected technology} makes it easier to do my job.	2.88	1.13	0.90	
	Use of {selected technology} enhances my effectiveness on the job.	2.75	1.16	0.89	
Simplicity of Use (Complexity)	Learning to use {selected technology} is easy for me.	3.21	0.95	0.87	Ayyagari et al. (2011)
	{selected technology} is easy to use.	3.20	0.95	0.92	
	It is easy to get results that I desire from {selected technology}.	3.01	0.99	0.80	
Reliability	The features provided by {selected technology} are dependable.	2.93	0.95	0.91	Ayyagari et al. (2011)
	The capabilities provided by {selected technology} are reliable.	2.93	0.94	0.93	
	{selected technology} behaves in a highly consistent way.	2.92	0.96	0.86	
Anonymity	It is easy for me to hide how I use {selected technology}.	1.85	1.22	0.80	(Ayyagari et al., 2011)
	I can remain anonymous when using {selected technology}.	1.79	1.29	0.80	
	It is easy for me to hide my {selected technology} usage.	1.72	1.23	0.92	
	It is difficult for others to identify my use of {selected technology}.	1.75	1.22	0.76	
Mobility	The use of {selected technology} is not limited to the workplace.	2.68	1.42	0.76	Self-developed with input from Tarafdar et al. (2007)
	The use of {selected technology} is not restricted to a certain location.	2.61	1.44	0.86	
	It is possible to use {selected technology} on the go.	2.53	1.50	0.93	
	{selected technology} is accessible from anywhere.	2.51	1.43	0.89	
	{selected technology} enables me to work anywhere.	2.40	1.41	0.80	
Reachability (Presenteeism)	The use of {selected technology} enables others to have access to me.	2.69	1.31	0.92	Ayyagari et al. (2011)
	{selected technology} makes me accessible to others.	2.67	1.32	0.95	
	The use of {selected technology} enables me to be in touch with others.	2.74	1.29	0.95	
	{selected technology} enables me to access others.	2.77	1.28	0.95	
Pace of Change	I feel that there are frequent changes in the features of {selected technology}.	1.82	1.24	0.92	Ayyagari et al. (2011)
	I feel that characteristics of {selected technology} change frequently.	1.74	1.20	0.94	
	I feel that the capabilities of {selected technology} change often.	1.78	1.22	0.94	
	I feel that the way {selected technology} works changes often.	1.70	1.21	0.92	
Pull	{selected technology} displays information only when I actively interact with	2.04	1.29	0.75	Self-developed
	To receive information through {selected technology} I need to actively	2.03	1.35	0.83	
	Information is provided by {selected technology} only on request.	2.11	1.33	0.85	
Push	{selected technology} displays information. whilst I am otherwise engaged.	2.36	1.18	0.75	Self-developed
	I automatically receive news/through information {selected technology}	2.48	1.13	0.89	
	{selected technology} uses push notifications to provide information.	2.59	1.15	0.74	
Intangibility of Results	The result of my work with {selected technology} is not tangible.	1.53	1.27	0.89	Self-developed
	The result of my work with {selected technology} is not clearly visible.	1.55	1.25	0.90	
	{selected technology} creates products that are not tangible.	1.56	1.26	0.84	
	The result of working with {selected technology} is not noticeable.	1.46	1.24	0.88	
	Results from the use of {selected technology} are not visible to third parties.	1.69	1.27	0.65	
	Third parties can not immediately see changes caused by using {selected	1.89	1.26	0.60	

2. Segmentation Preference and Communication Technology Adoption: The Boundary Transcending Effects of Technostress

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Submitted in: Information & Management

Abstract:

Remote work is becoming the "new normal", and more people are working in the home office due to the COVID-19 pandemic. In this context, we add on to a current research stream on technostress, investigating technology driven spillover in a longitudinal study based on data assessed during the pandemic. The use of communication technologies leads to work-family conflict due to the occurrence of techno-stressors interruptions, invasion, and overload. The individual preference to separate or integrate business and private life domain thereby influences technology adoption and how often certain channels are used for business communication. Further, differences between segmenters (people with a strong wish for separation) and integrators (who rather integrate life domains) were found. They experience techno-stressors differently in dependance of their technology use. Our paper offers interesting theoretical insights into boundary transcending effects of technostress. Recommendations for employers how to shape the "new normal" are discussed.

Keywords: technostress; segmentation preference; work-family conflict, longitudinal-study

2.1. Introduction

Due to the COVID-19-pandemic, we are faced with an unprecedented challenge all over the world. In Germany, contact restrictions and measures to prevent the spread of the corona virus were introduced almost overnight. An effective way to reduce personal contacts and thereby lower infections was the introduction of home office (or telework respectively) (Fadinger & Schymik, 2020) which affected many workplaces where it had not been a standard practice before the pandemic. When work is transferred into the home office, it transforms the workplace from a narrowly defined and time- and location-bound place towards a virtual and digital workplace (Zuppo, 2012). The pandemic has greatly accelerated this shift of work into the homes (Allen et al., 2021).

Digital technologies (DTs) build the foundation of the digital workplace by connecting people, processes and information and removing barriers (Attaran et al., 2020). Communication and collaboration tools increase "the productivity of the workforce in the information age" (Attaran et al., 2019, p. 1). Hence digital workplaces are an advantage in the battle of the pandemic, make businesses more agile and competitive, and help employees be more effective (Attaran et al., 2019, 2020). However, research has also shown that the use of DT may cause stress, which is referred to as technostress (Tarafdar et al., 2007). Technostress is associated with negative consequences for the well-being of individuals as well as their job performance (Ayyagari et al., 2011; Califf et al., 2020; Khaoula et al., 2020; Tarafdar et al., 2007).

One aspect of technostress that is especially relevant when work is transferred into the homes, is the problem of blurring of boundaries between work and private life (Tarafdar et al., 2007) and the negative spillover of demands from work into the private domain as well as the other way round which is facilitated by digital technologies (Benlian, 2020). Work-home interference has even been identified as one out of four key challenges for remote working employees during the pandemic (Wang et al., 2021). A recent study shows that the level of technostress (i.e., invasion which refers to the blurring boundaries) has increased in the year of the COVID-19 outbreak, compared to earlier years (Nimrod, 2020). Accordingly, this is an important topic for research in the light of the pandemic. Further, too many interruptions in the leisure time via mobile technologies are a source of stress leading to work-family conflict and lower adoption of IS in the workplace (Tams et al., 2020). Hence, the investigation of technostress should not be limited to the workplace and associated outcomes, but it needs to include the examination of the phenomenon in the home (office) and private domain. Also, individual characteristics, like the preference to keep private and business lives (and associated roles) apart or to integrate them, determines the relationship between cross-domain technology use and job stress and performance (Yeh et al., 2020).

In this manuscript, we follow the call by Benlian (2020, p. 1278) that research should focus on the investigation of cross-domain outcomes of technostress and "boundary-transcending spillover mechanism" which has become an important question with the unprecedented number of remote working employees due to the pandemic. Moreover, many insights on technostress are based on cross-sectional investigations (Benlian, 2020) and longitudinal studies are needed that examine within-person effects.

We contribute to the research stream by investigating the spillovers effect of technostress dissolving the boundaries between business and private life, with the goal to answer the question whether segmentation preference can be considered an antecedent of technostress leading to work-family conflict in the long run through adoption of DTs. Therefore, we assess data at two points of time during the COVID-19-pandemic. The following research questions guide our work:

R1: Does the individual preference to integrate or separate different life domains influence adoption of digital technologies for business purposes?

R2: Does technology adoption lead to technostress in different ways for individuals with different preferences to integrate or separate life domains?

R3: Does the occurring technostress which is related to blurring of domains promote role conflict?

To answer the research questions, the manuscript at hand is structured as follows: First, we give an overview of current research streams and relevant theory in the theoretical background. Next, we present our conceptual model and related hypotheses that guided our empirical analysis. Then, the results are presented. To wrap up, they summarized and discussed, highlighting the contribution of this manuscript from both practical and theoretical perspective. To conclude, an outlook on future research is given.

2.2. Theoretical Background

2.2.1. Boundary Management Efforts

According to boundary theory (Ashforth et al., 2000), individuals like to construct 'mental fences' around different domains of life to simplify their world. With each domain, different roles are associated. For example, in the private domain, the spouse or children have different expectations at an individual (role as husband/wife/father/mother) than the team leader at work (role as employee). The separation of roles helps to juggle demands and behavioral requirements stemming from different contexts. However, individuals vary in the degree how much they like to integrate or segment the domains and allow permeability of the borders between them (Ashforth et al., 2000). They can be differentiated in so-called segmenters and integrators (Derks et al., 2016; Kreiner, 2006). The former like to separate private and business life as much as possible whereas the latter prefer to integrate the two domains. Strong or weak segmentation is not "good" or "bad" per se but there are costs and benefits on both sides (Ashforth et al., 2000) and it is rather the fit between the individual preference and the reality of the situation that is important. If there is person-environment misfit, role conflict arises (Kreiner, 2006).

This issue is particularly relevant considering the intensified transfer of work from the office into the home during the COVID-19-pandemic and in consequence dissolving physical boundaries between the two domains. As the choice for home office is no longer a voluntary decision of the employee but is expected as individual contribution to the battle against the corona virus, this might lead to misalignment (Allen et al., 2021) in dependence of the segmentation preference. Literally, the work moves into the home. Correspondingly, boundary management has moved to the focus of research interest and first evidence provides contradictory results: People with high segmentation preference showed better work-nonwork balance in the home office (Allen et al., 2021) contradiction the expectations that the forced "integration" of the workplace into home leads to negatives outcomes due to the misalignment. Therefore, additional investigations are needed which raises the question of the processes and mechanisms between segmentation preference and role conflict.

2.2.2. Spillover Effects and Technology Adoption

DTs facilitate blurring of boundaries causing spill-over of demands from the work into the private domain on a daily basis (Benlian, 2020). For integrators, smartphone use in the evening may be beneficial to reduce role conflict while there was no such effect for segmenters (Derks et al., 2016). Further, too many interruptions in the leisure time via mobile technologies are a source of stress leading to work-family conflict and lower adoption of DTs in the workplace (Tams et al., 2020). Research has identified that the effect of segmentation preference on work-home conflict is mediated by work-related DTs use at home (Yang et al., 2019). Additionally, research indicates that causality also flows the other direction: Overload through frequently occurring technology enabled interruptions impacts work related technology use mediated by the experience of work-life conflict (Tams et al., 2020). Interruptions, overload and invasion have early been identified as aspects linked to the use of DTs which put the user at risk for perceiving (techno)stress (Galluch et al., 2015; Tarafdar et al., 2007).

2.2.3. Technology-Driven Demands

Overload, invasion, complexity, insecurity, and uncertainty are among the most studied technology-driven demands. These were introduced by Tarafdar et al. (2007) as part of the technostress framework (referred to as technostress creators or techno-stressors respectively). In the framework, drawing upon the transactional theory (Lazarus & Folkman, 1984) as an appraisal based approach, technostress is perceived when the demands that arise from the use of DTs are interpreted as a threat for the well-being and the resources are deemed to not be sufficient to handle this threat; or as Tarafdar et al. (2007, p. 304) state "technostress is caused by individuals' attempts and struggles to deal with constantly evolving ICTs and the changing physical, social and cognitive requirements related to their use".

Two of the five aspects are especially relevant in the context of home office in times of the pandemic and spillover over caused by digital technologies: Techno-overload refers to situations with overwhelming workload due to digital technologies which urges users to work faster and longer. Techno-invasion refers to the invasive effects of digital technologies and the resulting feeling of blurring boundaries between work and private domains (Tarafdar et al., 2007).

Techno-interruptions are considered another technology-driven demand (Galluch et al., 2015) going beyond the core-framework of technostress. This is in line with current findings where technical problems, disruptions (in the workflow or meetings), communication overload, and continuing work tasks at home were identified as stressful events related to DT use (Braukmann et al., 2018).

These technological demands can induce technostress because they are associated with adverse effects for the well-being and organizational performance of the individual: For example, exhaustion (Gaudioso et al., 2017), detachment (Pfaffinger et al., 2020), lower job satisfaction (Califf et al., 2020), reduced innovation potential (Chandra et al., 2019), decreased productivity and performance (Tarafdar et al., 2007; Tarafdar et al., 2015), and higher turnover intentions (Califf et al., 2020). Hence technostress is an important issue for organizations which employers should address to preserve a healthy, productive, innovative, and loyal workforce that benefits from digital transformation. Especially as a large part of their staff excessively relies on DTs and the technological equipment in the home office during the pandemic.

2.3. Conceptual Model and Hypotheses

We are interested in the boundary transcending effects of technostress and the intermediate processes between segmentation preference and work-family conflict. Based on the theoretical foundation and prior research presented above, we assume the following relationships between the study variables of interest (see Figure 1).

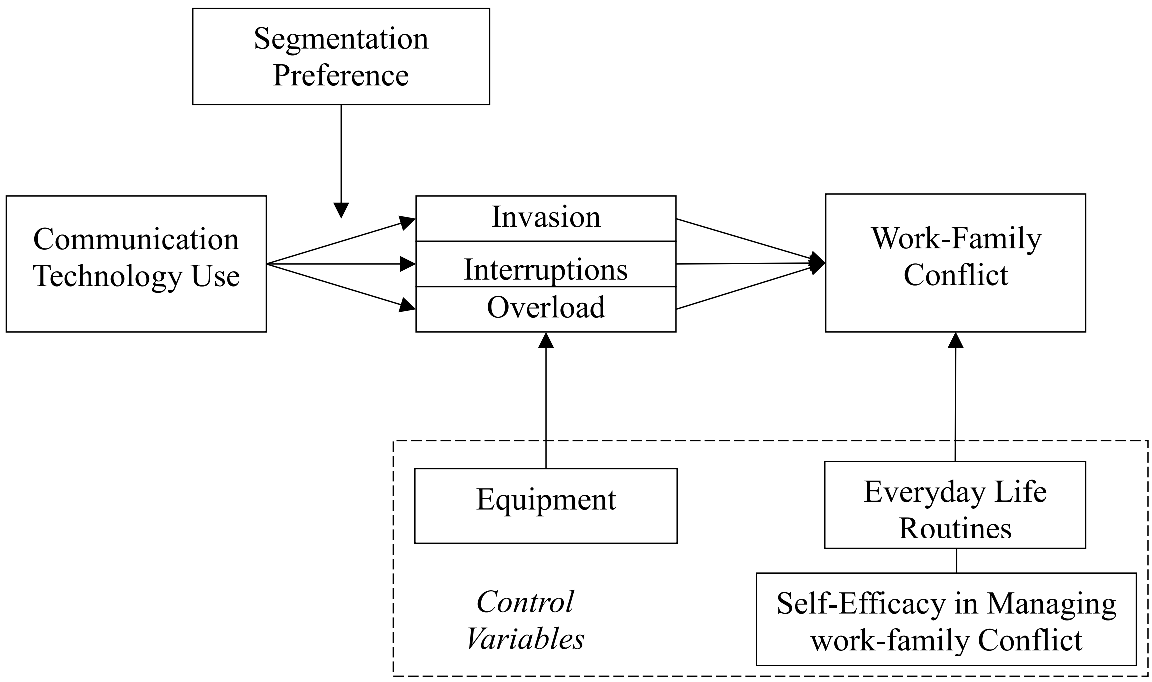

Figure 1. Simplified Conceptual Model.

Stress and interruptions resulting from the use of DTs determines the extent to which technologies for work purposes are used. Moreover, the effect of segmentation preference on work-family conflict is meditated by technology use. So accordingly, we propose that the individual segmentation preference influences adoption of communication technology.

Hypothesis 1: Segmentation preference determines the frequency with which four common communication technologies are used for business purposes.

The use of DTs can be perceived demanding for employees which can results in technostress. Further, there is no research concerning the interrelation of segmentation preference and techno-stressors. While differences between segmenters and integrators were identified regarding the effect of smartphone use in the leisure time, yet we believe that this difference is not limited to the smartphone and the private domain. Differences between segmenters and integrators and their technology use are also expected to be evident in the business context. Hence, we suppose:

Hypothesis 2: The use of four common communication technologies is related to the experience of techno-stressors invasion, overload and interruptions.

Hypothesis 2a: The perception of techno-stressors due to the use of four common communication technologies differs between segmenters and integrators based on their segmentation preference.

Further, we believe that the technology induced spillover of work demands into the private domain is related to the experience of the techno-stressors. So, we assume:

Hypothesis 3: The techno-stressors invasion, overload and interruptions are related to the experience of work-family conflict.

2.4. Method

A longitudinal study was conducted. It was the aim to provide evidence for the boundary transcending spill-over of communication technology use via technostress. All constructs were assessed at two measurement occasions and regressed on each other at the different points in time giving insights into the causal relationships. In the following we will describe in detail the data collection procedure, the sample, and the measures.

2.4.1. Data Collection

Data was collected during the first and second wave of the corona-virus pandemic in Germany. The first sample (measurement time t_1) is based on the data from May 2020 and the second sample (measurement time t_2) was collected in November 2020. Because the data collection is embedded in the context of a large research project, only persons were interrogated that had taken part in a previous survey in 2019. Individuals who did not change their employer since then and who experienced no major changes in their work settings (like change of department or short-time work) were selected. An external research panelist was instructed to collect the answers and participants were matched based on their panel ID. They were paid 3.70$/3.10€ as incentive for filling out the survey.

2.4.2. Sample

Overall, 637 respondents filled out the questionnaire at both time points. Representativity for the German workforce was reviewed carefully. The demographic properties of the sample are displayed in Table 1.

Table 1. Demographic Information of the Sample

	n	%	*M*	*SD*
Age	637	100	46.93	10.05
Gender				
Male	375	58.87		
Female	262	41.13		
Education				
Primary/lower secondary school graduation certificate	6	0.94		
Intermediate school graduation certificate	62	9.73		
Higher education entrance qualification	49	7.69		
Apprenticeship	219	34.38		
University degree (bachelor's)	113	17.74		
University degree (master's)	157	24.65		
Doctorate	31	4.87		

2.4.3. Measures

The survey relied on established items and scales in most parts. All questions were administered in German. For some scales, we used own translations that had been developed and extensively tested in prior research of the project. All constructs were assessed at both measurement times. If not indicated differently, answers were given on a five-point Likert type rating scale from 0 = *I do not agree at all* to 4 = *I totally agree*.

Segmentation preference was measured with four items (Kreiner, 2006). For example: *"I don't like work issues creeping into my home life."*

Invasion and overload were assessed with the scales provided by Ragu-Nathan et al. (2008). Invasion has three items (e.g., *"I feel my personal life is invaded by this technology."*) and overload consist of four items (e.g., *"I am forced by this technology to work with very tight time schedules."*).

Technology adoption was defined as the usage frequency of four common communication technologies at work: e-mail, instant messaging, audio and video tools. Participants were provided with different examples for popular instant messengers (e.g., Slack and WhatsApp), audio (e.g., telephone), and video conferencing tools (e.g., MS Teams and ZOOM). We asked: *"How often do you use [technology 1-4] for business communication?"* A five-point frequency scale was used: 0 = *never*, 1 = *several times a year*, 2 = *several times a month*, 3 = *several times a week,* 4 = *daily*.

Work-family conflict was measured with the scale by Brett and Stroh (2003). It comprises five items, for example *"feeling that your job interferes with your family life."* The frequency scale ranged from 0 = *never*, 1 = *rarely*, 2 = *from time to time*, 3 = *often*, to 4 = *very often*.

In addition to the study variables of interest, we included three control variables in the survey. The first one was the general availability of home office equipment. It was adapted from the Questionnaire for the Analysis of Mobile Work – Amobile (Kraus & Rieder, 2018). The wording was adopted to fit the context of teleworking employees. It covers four items (e.g., *"I have the necessary equipment available to perform my job in the home office").*

Secondly, we controlled for everyday life routines. Four self-developed items were used (e.g., *"How often do you begin your working day at the same time?"*). The scale was 0 = *never/rarely*, 1 = *seldom*, 2 = *sometimes*, 3 = *often*, 4 = *always/most times*.

The third control variable was self-efficacy in managing work-life conflict. It was measured with the Self-Efficacy for Work–Family Conflict Management Scale (Hennessy & Lent, 2008) (e.g., *"How confident are you that you could manage incidents in which work life interferes with family life?"*). It includes 10 questions rated on a five-point scale from 0 = *complete lack of confidence* to 4 = *total confidence*.

2.5. Results

We analyzed the data using covariance-based structural equation modelling (SEM). Before turning to answer the research questions, we carefully analyzed the data quality, the properties of the scales and the measurements model. The results and details are included in Appendices A to C. In a preliminary step, we inferred whether common method bias is a problem. For this, Harman's single factor test (Harman, 1967) was carried out. In an exploratory factor analysis several components were extracted, and the first unrotated factor accounted for about 25 % of variance which seems uncritical. Common method bias was further addressed by controlling for a common latent factor (Podsakoff et al., 2003) on which all items loaded in addition to their respective construct. Covariances with the other constructs were restricted to zero. In the SEM analyses, maximum likelihood estimation with robust standard errors and a Satorra-Bentler scaled test statistic were used to obtain parameters. Fit was judged according to the following standards (see Table 2):

Table 2. Thresholds Values to Evaluate Model Fit.

Fit Measure	Threshold	Source
CFI	> 0.90	Gefen et al. (2000)
TLI	> 0.90	Gefen et al. (2000)
RMSEA	< 0.06	(Lei & Wu, 2007)
SRMR	< 0.05	Gefen et al. (2000)

2.5.1. Segmentation Preference and Communication Technology Use

We first assessed how segmentation preference influences technology adoption. Therefore, in the SEM model, the use of the four communication tools (t_2) was regressed on segmentation preference (t_1). Home office equipment (t_1) was included as control variable. The fit of the model was reasonably good (CFI = 0.99, TLI = 0.99, RMSEA = 0.04, SRMR = 0.03). It was not surprising, that the effects of the control variable were significant. The availability of the equipment influences how often e-mails ($Est = 0.22$, $z = 4.87$, $p < .001$), instant messaging ($Est = 0.27$, $z = 6.67$, $p < .001$), as well as audio ($Est = 0.23$, $z = 5.40$, $p < .001$) and video tools ($Est = 0.38$, $z = 10.02$, $p < .001$) are used.

Segmentation preference is negatively related to the use of instant messaging (*Est* = -0.10, z = -2.23, $p < .05$) and positively to audio communication (e.g., making phone calls) (*Est* = 0.10, z = 2.32, $p < .05$). The participants use less messengers but make more phone calls. Hence, the adoption of certain communication tools depends on the segmentation preference of the individual.

2.5.2. Segmenters vs. Integrators Experience of Techno-stressors

In the next step, we wanted to find out how the use of communication technologies potentially induces technostress. To understand how segmenters (people who prefer strong boundaries) or integrators (who prefer more permeable boundaries) experience technostress differently due to their use of communication tools, a latent multigroup comparison was performed. The predictor variables (communication tool use) were assessed at t_1, while the criterion (the three technostress creators) was measured at t_2. It was controlled for daily routines (t_1), expecting an effect on invasion. Via median split, two groups were dichotomized based on their segmentation preference at t_1. In the first step, different models with varying constraints on parameters were fit to determine the degree of measurement invariance. The $\chi 2$ difference test of the fit indices is displayed in Table 3.

Table 3. Test of Measurement Invariance for the Multigroup Analysis.

	Df	AIC	BIC	χ^2	$\Delta\chi^2$	Δ *Df*
Configural invariance	172	19454.82	20078.76	258.29		
Metric invariance	193	19438.83	19969.19	284.31	20.57	21
Scalar invariance	201	19437.90	19932.60	299.37	16.58	8*

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Fit indices were almost equal in the four tested model, only deviating at the second decimal place. The difference test shows that the scalar invariance model fits worse than the metric invariance model which is supported by AIC that shows the lowest value for that model. Hence, equal factor loadings across groups were specified in the multigroup analysis. Overall, model fit was good: CFI and TLI and RMSEA showed good fit (CFI = 0.99, TLI = 0.98, RMSEA = 0.03,) SRMR was slightly above the threshold value (SRMR = 0.05) rounded to the second decimal.

The results of the comparison are reported in Table 4. First, the effect of the control variable was assessed. Daily routines are significantly negatively related to the techno stressor invasion for the integrators. There were no other significant effects of the covariate. Controlling for the effect of routines, differences in the regression paths between groups are evident.

Table 4. Results of the Multigroup Analysis.

	Segmenters			Integrators		
Tool	*Est*	*SE*	*z*	*Est*	*SE*	*z*
			Interruptions			
Daily routines	-0.08	0.09	-1.20	-0.03	0.05	-0.42
E-mail	0.07	0.04	1.21	-0.26	0.05	-3.99***
Instant messaging	0.01	0.04	0.08	0.04	0.04	0.50
Audio	0.03	0.04	0.38	-0.04	0.04	0.54
Video	0.07	0.05	0.81	0.12	0.04	1.49
			Invasion			
Daily routines	-0.03	0.11	0.43	-0.16	0.07	-2.44*
E-mail	-0.12	0.05	-1.73	-0.22	0.05	-3.43**
Instant messaging	0.09	0.03	1.42	0.14	0.04	2.31*
Audio	-0.08	0.03	-1.24	0.00	0.04	0.01
Video	0.17	0.04	2.50*	0.09	0.04	1.36
			Overload			
Daily routines	-0.01	0.12	-0.10	-0.12	0.07	-1.87
E-mail	0.01	0.05	0.20	-0.21	0.05	-3.56***
Instant messaging	0.07	0.04	0.95	-0.05	0.04	-0.71
Audio	-0.11	0.04	-1.52	-0.01	0.04	0.15
Video	0.18	0.05	2.40*	0.21	0.05	2.75**

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

For ‘segmenters’ the use of video communication tools (i.e., virtual conferences) is associated with the techno stressor invasion. integrators in comparison experience less interruptions, invasion and overload using e-mails for communication. At the same time, instant messaging is related to invasion and the use of video tools is related to overload for this group.

2.5.3. Technostress and Role Conflict

In the next step, the lower part of the conceptual model was analyzed to find out how technostressors relate to role conflict. Work-family conflict at time t_2 was regressed on technostress creators at measurement time t_1 to ascertain if the experience of stressors leads to role conflict due to spillover effects. It was controlled for daily routines (t_1) and self-efficacy in managing work-family conflict (t_1). Table 5 reports the results. Model fit was good. CFI was 0.96, TLI was 0.95, SMRM was .05 and RMSEA was 0.06. Self-efficacy was associated with lower work-family conflict. No effect was observed for daily routines. Both, invasion and overload were positively related to work-family conflict, indicating a technology related spillover effects of demands into the private domain.

Table 5. Results for the Prediction of Work-Family Conflict at Measurement Time 2

Predictor	Work-family conflict		
	Est	*SE*	*z*
Self-efficacy	-0.23	0.04	-4.41^{***}
Daily routines	0.03	0.03	0.78
Interruptions	0.09	0.04	1.38
Invasion	0.22	0.04	3.74^{***}
Overload	0.19	0.05	2.64^{**}

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

2.6. Discussion

Our findings provide important insights into the boundary transcending spillover effects of technology use. We found that the preferences of an individual influence the frequency with which communication technologies are adopted for business purposes. Employees tend to avoid instant messaging while at the same time make more phone calls with increasing wish to keep private and business matters apart.

Moreover, distinguishing between segmenters (i.e., people who prefer strong boundaries) and integrators (i.e., people who rather integrate the life domains), we found that they perceive technology-driven demands differently due to their use of communication technologies. E-Mail communication is beneficial for integrators. They experience less invasion, interruptions and overload. Video communication on the other hand seems to have strong potential to cause technostress. Both groups experience overload due to the use. Segmenters additionally experience invasion because video conferencing. Further integrators experience invasion using instant messaging.

Lastly, looking at the spillover effects of work into the private domain, we found that overload and invasion are related to work-family conflict.

The fact that video calls lead to invasion for segmenters might have a simple explanation. Through the video, the conversation partner gets a direct insight into the living room and thus also the private life. More than with any other communication medium. Thus, it leads to the perception of blurring boundaries as the opposite virtually "invades" the home. Moreover, the invasive effects of instant messaging may be due to the characteristic push (Becker et al., 2020), which is positively related to perception of invasion. Usually, messengers inform the person actively about incoming messages signaling them via a tone or blinking light. Therefore, it is surprising on the other hand, that no relation between instant messaging and interruptions was found.

Regarding the positive effects of the use of e-mails for segmenters: having the possibility to check e-mails on the run and even on vacation could provide reassurance. Knowing that nothing important happened and there are no burning topics during absence can be helpful to switch off and mentally detach from work. Maybe shortly replying to an e-mail even hinders further disturbances like a phone call. So, for integrators using e-mails may help juggle demands and can be beneficial.

2.7. Theoretical Contribution

With this paper, we contribute to current research in several ways. (1) We appeal to the call by Benlian (2020) to investigate the boundary transcending effects of digital technologies and conducted a longitudinal study. By modelling the relationship between our variables at different time points, we provide first evidence for causal effects between technology adoption, technostress its spillover effects causing role conflict.

(2) The results provide insights on technology adoption. In this context several models are discussed in research which try to explain what leads to acceptance of different technologies and their adoption. The most recognized one is probably the Technology Acceptance Model (TAM) by (Davis et al., 1989). Different expansions of the model have been proposed (Venkatesh et al., 2003). While these models include many individual characteristics like hedonic motivation, expectations of effort and performance, age, gender etc. (Venkatesh et al., 2003), we found another factor that directly influences adoption of technologies. Segmentation preference as a stable individual trait adds on to the list of factors which is related to technology use behavior.

(3) Further, we shed light on how technology environment conditions lead to technostress in different ways depending on an individual trait segmentation preference. Thereby we contribute to the current discourse about challenge and hindrance stressors and different outcomes of technostress as discussed by (Tarafdar et al., 2019).

2.8. Practical Recommendations

From the results, clear recommendations for employers and employees can be derived. Employees have different preferences for communication technologies depending on the degree to which they like to keep private and business lives apart. Accordingly, organizations should grant their employees freedom in choice of tools and provide a bandwidth of different communication technologies. Having strong guidelines regarding the technology choice in the company might be tempting but can be adverse with regard to technostress.

While video communication seems to be disadvantageous in terms of stress, we will not recommend the abolishment of virtual conferences. Research on digital leadership shows that trust is build up in face-to-face communication (Antoni & Syrek, 2017). While this is ceased in remote work, it seems hard to build the foundation for a good leader-member and team relationship in virtual environments. However, this is highly important in virtual teams as trust is related to team effectiveness (Breuer et al., 2016) – even stronger than in face-to-face teams. The trust problem can be tackled by transparent flow of information, structured communication of organizational decisions and avoiding the feeling of employees to be isolated (Ford et al., 2017). This can be reached through use of synchronous communication mediums like video calls and regular virtual conferences (Antoni & Syrek, 2017; Ford et al., 2017). Therefore, digital leadership should focus on effective media choice to enable trust in virtual communication (Antoni & Syrek, 2017).

Hence, organizations should empower their leaders for digital leadership by providing development possibilities and emphasizing the importance the topic media choice, virtual communication and technostress as downside of digital transformation. Understanding the interplay between individual preferences and the technologies provided by the employers is essential for leaders to reduce technostress for their employees and avoid adverse effects like turnover, decreased innovativeness or lower productivity.

Further, we have found effects of our control variable routines. We recommend that employees should try to maintain daily routines such as regular working hours and breaks even in the home office to reduce invasion and avoid spillover effects of work into the private sphere. Further, to reduce the feeling of invasion, disabling insights into the private rooms can be helpful. Modern tools nowadays provide the possibility to use customized backgrounds and screens so that the spouse, partner or the children in the background can be faded out by electronic means.

2.9. Limitations and Future Research

There are several limitations of our study. We used self-reported data on the use of communication and collaboration technologies. However, objective data from, for example, logfiles of the technology use could achieve a higher reliability of the results. Further, even though we collected longitudinal data, we did not use a cross-lagged panel design. Future research could thus set out to overcome these issues.

In conclusion, our research gives important insights on the negative effects of IT use in telework and home office during the COVID-19-pandemic. We also show the high importance of individual characteristics (segmentation preference) on their perception of technostress and their well-being. Thus, when creating the “next normal” of working after the current pandemic, research, employers as well as individuals themselves should consider these results in order to build a working environment in which the positive outcomes of telework and home office can be achieved while negative outcomes such as technostress can be avoided.

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2.12. Appendix A: Items and Scales Used in the Study

Table A1. Scales and Items in the Study.

Construct	Item
Segmentation preference	I don't like to have to think about work while I'm at home.
	I prefer to keep work life at work.
	I don't like work issues creeping into my home life
	I like to be able to leave work behind when I go home.
Communication technologies	How often do you use e-mail for business purposes?
	How often do you use instant messaging (e.g., MS Teams, Slack, WhatsApp) for business communication?
	How often do you use audio tools (e.g., phone calls, MS Teams, Skype) for business communication?
	How often do you use video tools (e.g., MS Teams, Skype, Zoom) for business communication?
Invasion	I have to sacrifice my vacation and weekend time to keep current on digital technologies.
	I have to be in touch with my work even during my vacation due to digital technologies.
	I feel my personal life is being invaded by digital technologies.
Overload	I am forced by digital technologies to do more work than I can handle.
	I am forced to work with very tight time schedules by digital technologies.
	I am forced to change my work habits to adapt to new technologies.
	I have a higher workload because of increased technology complexity.
Interruptions	I received too many interruptions during the task through digital technologies.
	I experienced many distractions during the task due to digital technologies.
	The interruptions caused by digital technologies are frequent.
Work-family conflict	feeling that you cannot accomplish everything you would like to at home.
	feeling that your job interferes with your family life.
	feeling that your job interferes with your personal time.
	feeling that you do not have enough time for your family.
	feeling that you do not have enough time for your friends.

Construct	Item
Everyday life routines	How often do you get up at the same time on working days?
	How often do you begin your working day at the same time
	How often do you make regular breaks on working days?
	How often do you got to bed at the same time on working days?
Self-efficacy in managing work-family conflict	How confident are you that you can fulfill your family role effectively after a long and demanding day at work?
	How confident are you that you could attend to your family obligations without it affecting your ability to complete pressing tasks at work?
	How confident are you that you could manage incidents in which work life interferes with family life?
	How confident are you that you could fulfill your family responsibilities despite going through a trying and demanding period in your work?
	How confident are you that you could manage incidents in which family life interferes with work life?
	How confident are you that you could fulfill your family role effectively after a long and demanding day at work?
	How confident are you that you could invest in your job even when under heavy pressure due to family responsibilities?
	How confident are you that you could succeed in your role at work although there are many difficulties in your family?
	How confident are you that you could invest in your family role even when under heavy pressure due to work responsibilities?
	How confident are you that you could focus and invest in work tasks even though family issues are disruptive?

2.13. Appendix B: Scale Quality

We checked the quality of the scales and descriptive statistics before the analysis of the SEM, including means, standard deviations, Cronbach's alpha, average variance extracted (AVE) and factor loadings (See Table A1). AVE and loadings were derived from a confirmatory factor analysis. All constructs were added at once and the latent factors were freely correlated. Alpha was good, as well as AVE. Only one item (daily routines 3) had to be excluded from the measurement model. It showed an unacceptably low loading and AVE was below 50. Other items' loadings were also below 0.70. However, these were not excluded because on average over all items more than 50% variance is explained by the latent underlying factor.

Table A2. Descriptive Statistics and Properties of the Scales in the Study.

Construct	*M*	*SD*	λ	α	AVE
$n_1 = 637$			Measurement time t_1		
Daily routines	2.99	0.99	.55-.91	.78	0.65
Home office equipment	2.29	1.48	.73-.94	.92	0.75
Segmentation preference	2.72	1.18	.70-.88	.91	0.66
E-mails	3.33	1.07	–	–	–
Instant messaging	1.63	1.56	–	–	–
Audio	2.25	1.59	–	–	–
Video	1.22	1.42	–	–	–
Interruptions	1.28	1.19	.90-.91	.93	0.82
Invasion	1.00	1.18	.60-.87	.81	0.60
Overload	1.36	1.26	.75-.89	.90	0.70
$n_2 = 637$			Measurement time t_2		
Daily routines	2.96	1.05	.60-.94	.80	0.70
Home office equipment	2.16	1.54	.72-.94	.91	0.74
Self-efficacy	2.66	1.01	.84-.88	.96	0.75
E-mails	3.49	1.01	–	–	–
Instant messaging	1.84	1.64	–	–	–
Audio	2.73	1.51	–	–	–
Video	1.64	1.47	–	–	–
Interruptions	1.31	1.18	.89-.89	.92	0.80
Invasion	1.02	1.21	.65-.85	.82	0.60
Overload	1.39	1.25	.78-.89	.92	0.73
Work-family conflict	1.48	1.14	.65-.89	.92	0.71

2.14. Appendix C: Measurement Model

Additionally, we looked at discriminant validity of the constructs because based on Cronbach's alpha no statement about dimensionality can be made. Therefore, latent correlations were extracted from the before mentioned confirmatory factor analysis. According to the Fornell-Larcker criterion, the square root of the AVE (printed bold in the diagonal of the table), should be higher than the inter-factor correlations (Fornell & Larcker, 1981). This was the case for all constructs. Hence discriminant construct is considered good.

Table A3. Discriminant Construct Validity According to the Fornell-Larcker Criterion.

	INV1	INV2	OVE1	OVE2	INT1	INT2	SEP1	WFC2	SEF1	HOE1	DR1
Invasion t_1	**0.77**										
Invasion t_2	0.76	**0.78**									
Overload t_1	0.57	0.46	**0.84**								
Overload t_2	0.48	0.65	0.72	**0.86**							
Interruptions t_1	0.56	0.41	0.72	0.56	**0.91**						
Interruptions t_2	0.41	0.60	0.59	0.81	0.66	**0.89**					
Segmentation Preference t_1	-0.35	-0.28	-0.02	-0.01	-0.03	0.02	**0.81**				
Work-family conflict t_2	0.44	0.48	0.46	0.58	0.42	0.51	-0.03	**0.84**			
Self-efficacy t_1	-0.22	-0.21	-0.33	-0.29	-0.29	-0.29	0.10	-0.36	**0.84**		
Home office equipment t_1	0.05	0.01	-0.03	-0.01	-0.04	-0.03	-0.15	-0.04	0.19	**0.87**	
Daily routines t_1	-0.34	-0.26	-0.19	-0.17	-0.21	-0.15	0.30	-0.15	0.20	0.03	**0.81**

3. Mitigating the Negative Consequences of ICT Use: The Moderating Effect of Active-Functional and Dysfunctional Coping

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Abstract:

With progressing digitalization, negative consequences resulting from the use of information and communication technologies at work are an important topic of debate. With this paper, we contribute to the current discourse by examining how employees mitigate technostress. We transfer theory from psychology to information systems literature by investigating a moderated mediation model where coping was conceptualized as a personal resource in line with the job demands-resources model. The moderating effects of two different reactive coping strategies—active-functional and dysfunctional—were investigated within a final sample of 3,362 German knowledge workers. We found a competitive mediation effect where the direct effect of demands on productivity is of opposite direction as the indirect effect. Both active-functional and dysfunctional coping reduce the extent to which demands lead to strain. The contribution of this paper for technostress research is discussed and implications for future research are given. Recommendations for employers and employees are highlighted.

Keywords: negative consequences of ICT use; technostress; strain; coping; active-functional coping; dysfunctional coping

3.1. Introduction

Digital transformation is driven by a wide variety of digital technologies and their adoption (Hartl, 2019; Osmundsen et al., 2018). Even though many opportunities and chances accompany this development (e.g., products and services can be offered in less time or with better quality), there are some downsides. In particular, the use of information and communication technologies (ICT) may cause stress. Research has noted this as technostress (Brod, 1984; Tarafdar et al., 2007).

Several aspects which demand employees due to their increased usage of digital technologies at the workplace have been identified (Ragu-Nathan et al., 2008; Tarafdar et al., 2007). It has been shown that these technology-related factors which can induce stress (commonly referred to as technostress creators or techno-stressors (cf. Tarafdar et al., 2019)) potentially lead to reduced well-being (Atanasoff & Venable, 2017) of the individual and lower organisational performance (Ayyagari et al., 2011; Califf et al., 2020; Khaoula et al., 2020; Srivastava et al., 2015; Tarafdar et al., 2010; Tarafdar et al., 2011). Hence, the impact of digitalization on an employee's working environment must be regarded as ambivalently (Apt et al., 2016), with technostress representing an important issue in occupational settings (Ayyagari et al., 2011; Tarafdar et al., 2007; Tarafdar et al., 2010).

Due to this relevance, organisations aim to minimise the risk that their employees experience technostress at the workplace. Existing studies in this realm have identified several "organizational mechanisms that have the potential to reduce the effects of technostress" (Ragu-Nathan et al., 2008, p. 422). These "technostress inhibitors" can address technostress on an organisational level, implemented as ex-ante measures to prevent the occurrence of technostress. However, these mechanisms do not answer the question how employees react in a given situation when they are excessively demanded through their use of digital technologies during their work routines.

Considering this gap, our work takes up the call for research by Tarafdar et al. (2019) regarding employees' efforts and reactions to mitigate technostress which is seen as a still understudied research area. Recent work has already responded to this call, focusing on inherently stable personality traits (Pflügner et al., 2020; Sumiyana & Sriwidharmanely, 2020) or coping in general (Nisafani et al., 2020). Admittedly, research regarding the preference of different coping strategies is scarce. For example, Pirkkalainen et al. (2019) examined the difference between pro-active coping and re-active coping, focusing on a temporal perspective with respect to coping preferences. A more differentiated consideration regarding the influence of re-active coping is not provided, although this appears relevant from a practical perspective in order to plan organisational measures for dealing with technostress. By providing this study, we aim to close this gap methodically following the examples of Frese (1986), Nisafani et al. (2020), and Pirkkalainen et al. (2019).

Since Tarafdar et al. (2019) also highlight the need for interdisciplinary enrichment, we aim to provide evidence that coping as a personal resource mitigates the negative effect of (techno)stress on health-related outcomes as proposed by the psychological theory of job demands-resources (JD-R) model (Demerouti et al., 2001). Thereby, we contribute to research by investigating the influence of technostress on organisational and individual-level outcomes in line with the workplace-specific JD-R. Furthermore, we emphasize the importance of distinguishing between functional and dysfunctional coping, two forms of reactive coping, to gather insights about the differentiation of effective and less effective ways to overcome technostress.

The present manuscript is structured as follows: first, we address the theoretical background regarding the negative consequences of ICT use and coping in current IS and psychology research. Subsequently, we propose a conceptual model that integrates the relationships between techno-stressors, health-related as well as organisational outcomes, and the moderating effect of individual coping behaviours. Afterwards, we present our method section and report our empirical results. Lastly, we summarize and carefully discuss our findings and give an outlook for future research.

3.2. Theoretical Background

3.2.1. Technostress

The concept of technostress is anchored in the transactional theory of stress (Lazarus & Folkman, 1984). Stress is a process where individuals appraise the demands of a given situation as taxing or exceeding their resources while interacting with their environment. Consequently, technostress refers to stress that arises during ICT usage (Tarafdar et al., 2019). Tarafdar et al. (2007) emphasize that "in the organizational context, technostress is caused by individuals' attempts and struggles to deal with constantly evolving ICT and the changing physical, social, and cognitive requirements related to their use" (p. 304). Hence, employees might experience technostress due to an increased usage of ICT at the workplace (Ragu-Nathan et al., 2008).

The scholarly concept as it is known in IS was introduced by Tarafdar et al. (2007). While early work relating to the original framework (Ayyagari et al., 2011; Ragu-Nathan et al., 2008; Salanova et al., 2013; Tarafdar et al., 2010; Tarafdar et al., 2011) was focused on the workplace with technostress as a downside of digital transformation in organisations, current research investigates the phenomenon in private settings as well (see e.g., Maier, Laumer, & Eckhardt, 2015; Maier, Laumer, Weinert, & Weitzel, 2015; Tarafdar, Maier, et al., 2020. Due to its relevance for both employees and employers, we primarily focus on technostress in work-specific contexts within this study. Other current research streams also include the design of stress-sensitive systems (Adam et al., 2017), the perception of stressors as challenge (including a discussion about eustress and distress (Benlian, 2020; Tarafdar et al., 2019)), and coping (Salo et al., 2020; Tarafdar, Pirkkalainen, et al., 2020), the latter being the research stream to which we contribute with the presented research.

Basically, stress may occur due to various stressors (i.e., stressful conditions) which demand individuals during a given situation (Galluch et al., 2015). In this context, several demanding aspects for employees related to the use of digital technologies have been identified (Tarafdar et al., 2007): Complexity refers to situations where employees do not feel able to handle job-related technologies due to a perceived lack of skills. Insecurity relates to employees' fear of being replaced by new technologies or other employees, resulting in losing their job. Invasion is connected to blurred boundaries between work-related and private periods. Situations where employees have to work faster, longer, and even more due to ICT usage represent overload. At last, uncertainty describes employees' confusion in ICT use caused by new developments regarding the organisation's technologies. Besides, there are other aspects which are discussed as demanding: Riedl et al. (2012) investigated unreliability, which refers to ICT troubles like system breakdowns. Furthermore, a disturbed workflow through interruptions has been considered another technology-related stressor (Galluch et al., 2015). Too many interruptions in the leisure time via mobile technologies are a source of stress leading to work-family conflict and lower adoption of IS in the workplace (Tams et al., 2018; Tams et al., 2020). This is in line with current findings where technical problems, disruptions (in the workflow or meetings), communication overload, and continuing work tasks at home were identified as stressful events related to ICT use (Braukmann et al., 2018).

The described factors may lead to strain, which is defined as an employee's psychological, physical, or behavioural response to techno-stressors (Atanasoff & Venable, 2017). In this context, several studies have already dealt with different facets of strain like mental exhaustion (i.e., feeling burned out and drained (Ayyagari et al., 2011; Srivastava et al., 2015)), or problems of psychological detachment (Barber et al., 2019; Khaoula et al., 2020; Santuzzi & Barber, 2018). Furthermore, technostress is also associated with adverse organisational outcomes (e.g., lower productivity (Tarafdar et al., 2007; Tarafdar et al., 2015), lower user satisfaction (Fischer & Riedl, 2020), and lower employee's loyalty to the employer (Tarafdar et al., 2011)).

To reduce technostress, Ragu-Nathan et al. (2008) investigated three situational factors and organisational mechanisms: technical support, literacy facilitation (users are encouraged to share their experiences with and knowledge about new technologies), and involvement facilitation (users are consulted in the implementation of new technologies and are actively encouraged to try them out). These technostress-inhibitors operated as moderators of the relationship between technostress and job-satisfaction, organisational commitment, and continuance commitment. Furthermore, individual moderating variables like technology self-efficacy (Tarafdar et al., 2015) and personality traits like big five openness, agreeableness, neuroticism, conscientiousness and extraversion (Srivastava et al., 2015) have been identified.

3.2.2. Different Styles of Coping

Coping describes the "constantly changing cognitive and behavioural efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person" (Lazarus & Folkman, 1984, p. 141). These efforts are commonly classified into different styles of coping. Besides the broadly acknowledged distinction between problem-focused coping (directed at the problem itself in terms of modifying or improving the person-environment relation) and emotion-focused coping (comprising strategies which aim at regulating stressful emotions) proposed by Folkman et al. (1986), more fine-grained taxonomies include active coping, seeking instrumental social support, religion, positive reinterpretation, mental disengagement or behavioural disengagement—only to name a few (Carver et al., 1989). In a more detailed approach, 14 different coping styles have been differentiated (Carver, 1997). Thereby, active coping and seeking instrumental social support can be subsumed under problem-focused coping, whereas positive reinterpretation and turning to religion are examples of positively related emotion-focused coping. Hence, these two higher-level categories reflect active-functional strategies (Prinz et al., 2012). In contrast, coping strategies where individuals try to avoid the overall issue and escape from the problem instead of tackling it at its source are considered dysfunctional. Examples are mental and behavioural disengagement as well as alcohol and drug consumption (Carver et al., 1989; Prinz et al., 2012).

Research using this more fine-grained taxonomy found that active coping is associated with lower exhaustion (Gaudioso et al., 2017). The use of active-functional strategies, such as seeking social support, is negatively associated with burnout (Erschens et al., 2018). It has also been observed that maladaptive, dysfunctional coping like behavioural disengagement is associated with increased work exhaustion (Gaudioso et al., 2017; Prinz et al., 2012) and strain (Hauk et al., 2019). In total, there is some evidence that active-functional coping strategies positively influence employees' well-being and organisational outcomes, whereas dysfunctional coping negatively impacts those outcomes.

There is no consensus in research whether coping strategies should be considered a moderator or mediator. Frese (1986) mentioned this issue in his study and highlights that this specific distinction is often neglected. Several studies have addressed the mediation effect of coping in the context of technostress research (Gaudioso et al., 2016; Hauk et al., 2019; Xi Zhao et al., 2020). Maladaptive coping, for example, translates invasion and overload through the strain facets of work-family conflict and distress into higher exhaustion. In contrast, adaptive coping strategies mediate the same relationship resulting in lower work exhaustion (Gaudioso et al., 2017). Behavioural disengagement mediates the relationship between age and technology-induced strain operationalized as emotional and physical exhaustion (Hauk et al., 2019).

3.2.3. Coping Portfolio as a Personal Resource in the Job Demands-Resources Model

At the same time, stressors and work demands, which also include stress resulting from the use of ICT, constitute a typical subject of matter in psychological investigations (Barber et al., 2019; Braukmann et al., 2018; Day et al., 2010; Day et al., 2012; Golden, 2012; Sonnentag et al., 2010). In this context, coping strategies have been discovered numerous times as a moderating variable: Lewin and Sager (2009) found that problem-focused coping strategies moderate the impact of stressors on emotional exhaustion. Yip et al. (2008) provide evidence that coping buffers the negative effects of job stressors on burnout. Similarly, Searle and Lee (2015) found that pro-active coping moderates the relationship between demands and burnout. Ashill et al. (2015) show in their study that self-directed coping mitigates dysfunctional effects of job demand stressors on emotional exhaustion while other-directed coping buffers the relationship between job demands and job performance. Recently published articles in IS about technostress also started to model coping as a moderator (Nisafani et al., 2020; Pirkkalainen et al., 2019; Tarafdar, Pirkkalainen, et al., 2020).

Investigating coping as a moderator, psychological research widely uses the JD-R model (Demerouti et al., 2001), which is based on Hobfoll's conservation of resources theory (Hobfoll, 1989) that argues that an individual seeks to either increase the number of resources or preserve existing ones and stress is related to the loss or lack of resources, serving as an alternative to the perspective of the transactional theory of stress (Lazarus & Folkman, 1984). The JD-R has been developed and expanded over time to explain the relationship between job demands, personal resources, and strain (e.g., exhaustion as one facet of burnout (Demerouti et al., 2010)). According to the JD-R model, different workplace aspects can be categorized as either demands or resources. Job demands are physical, psychological, social, or organisational aspects of the job that require an individual's effort and skills. Examples of such job demands are workload, organisational changes, emotionally demanding interactions, and computer problems.

Accordingly, techno-stressors can be interpreted as job demands. In keeping with the JD-R model, “job resources refer to those physical, psychological, social, or organisational aspects of the job that may do any of the following: be functional in achieving work goals, reduce job demands and the associated physiological and psychological costs, stimulate personal growth and development” (Demerouti et al., 2001, p. 501). ”Personal resources can be seen as the beliefs individuals have in their ability to act on the environment” (Bakker & Demerouti, 2017, p. 275). Personal resources can buffer the impact of job demands on strain, while strain variables like exhaustion negatively affect employees’ job performance (Bakker & Demerouti, 2017).

The selection of coping measures suitable for a specific stressor from the personal perspective and the actual implementation depend on individual aspects such as personality, experience, age (Blaxton & Bergeman, 2017), and other resources provided by the organisation. For example, calling the IT-support as an example for problem-oriented coping in the area of technostress can only be applied if the organisation provides appropriate IT-support. On the other hand, it is also relevant during the selection process of an appropriate coping measure what possibilities to handle the stressor a person has or wants to use or whether a person tends to repeatedly use the same coping measures. Similarly, coping measures are selected from different coping strategies such as problem-focused vs. emotion-focused or active-functional vs. dysfunctional. In terms of the JD-R model, the above-mentioned individual aspects, referring to the perception whether an individual can control or influence a situation, correspond to personal resources (Tremblay & Messervey, 2011) and, for example, the IT-support to job resources (Xanthopoulou, Bakker, Dollard, et al., 2007) which thus arise in a direct relationship with the implementation of a coping measure. Hence, we argue the breadth and variety of an individual's portfolio of usable coping measures can be seen as a resource yet coping (the selection and application of coping measures regarding a specific stressor) is a complex process.

This is in line with other research modelling pro-active coping as a personal resource (Searle & Lee, 2015) coping strategies also can mitigate strain directly (Ângelo & Chambel, 2014).

Overall, the JD-R tries to determine the effects of the complex interplay of demands and resources with respect to employees' motivation and health. For example, deficiencies in work design or persistent excessive stress factors lead to the exhaustion of employees' mental and physical resources, which can have deleterious health effects. Simultaneously, resources reduce the influence of job demands on health-related effects (Bakker & Demerouti, 2007; Xanthopoulou, Bakker, Demerouti, & Schaufeli, 2007). Additionally, the availability of resources can lead to high commitment, low cynicism, and intrinsic motivation. Consequently, resources and coping measures play an important role in dealing with demands and influence the relationship between these and strain. Ultimately, the motivation and health of the employee determine the organisational outcomes.

The JD-R model has also been used as a theoretical foundation for conceptualizing technostress (Christ-Brendemühl & Schaarschmidt, 2020; Florkowski, 2019; Mahapatra & Pati, 2018; Ninaus et al., 2015; Wang et al., 2017) but it has not been applied in investigating coping strategies as a moderator in the technostress context yet. With this study, we aim to close this theoretical gap.

3.3. Research Model and Hypotheses Development

We are referring to the agenda postulated by Tarafdar et al. (2019) who claim a lack of research on coping strategies and their effects on the relationships between techno-stressors and outcomes. Simultaneously, other researchers (Nisafani et al., 2020; Pirkkalainen et al., 2019) call for further investigations of coping strategies and how they might lead to different coping outcomes. To fill this gap, the respective moderating effects of active-functional and dysfunctional coping behaviour are the focus of our examination. Another reason for this is that

Pirkkalainen et al. (2019) focus on the effects of proactive (i.e., strengthening one's ability to cope) and reactive coping, neglecting the different types of reactive coping. Based on the findings above, we developed a research model (the simplified moderated mediation model is displayed in Figure 1) based on the Job Demands-Resources model (Bakker & Demerouti, 2017) .

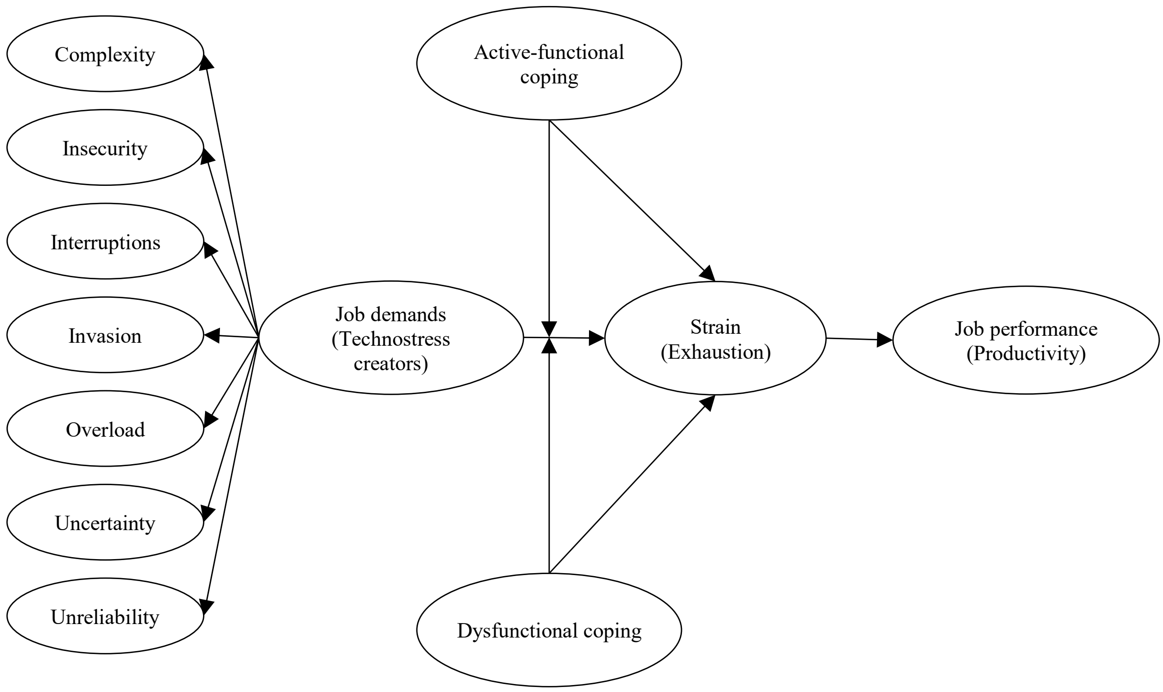

Figure 1. The Proposed Research Model of the Assumed Relationships in Accordance with Nisafani et al. (2020).

The model establishes a relation between job demands, strain (represented through exhaustion), and job performance (represented through productivity) - with strain mediating the impact of job demands on job performance - as well as the moderating effect of coping as a resource which is in line with the JD-R model (Bakker & Demerouti, 2017). Furthermore, the direct effect of coping on strain, as proposed by Ângelo and Chambel (2014), is included. To our understanding, the techno-stressors described above represent technology-related job demands resulting from the use of ICT for work purposes. The wording 'demands' will be subsequently used. Therefore, in the model, the second-order construct job demands comprises the five techno-stressors (Tarafdar et al., 2007) mentioned and explained above: complexity, insecurity, invasion, overload, and uncertainty. Also, interruptions and unreliability (ICT hassles) were identified as affective events related to ICT use that may have negative consequences for well-being (Braukmann et al., 2018).

It has been shown that technostress is associated with lower productivity and simultaneously, techno-stressors can induce strain. In line with the proposed model, we deduct hypotheses for the relationships between job demands, exhaustion, productivity, and coping. According to the JD-R model, it takes mental and physical capacity to handle job demands. This loss of capacity ultimately affects organisational outcomes. Further, the JD-R model proposes that strain translates into lower job performance, so we assume:

Hypothesis 1a: Job demands are negatively associated with the productivity of employees.

Hypothesis 1b: The relationship between job demands and productivity is mediated by exhaustion

In contrast to Tarafdar, Pirkkalainen, et al. (2020) who investigated the moderating effect of coping between technostress creators and IT-enabled productivity, in the JD-R model, the association between demands and strain is moderated while productivity is downstreamed (mediation via strain) (cf. Figure 1). This is different to the understanding of "productivity as behavioural strain" (Tarafdar et al., 2010, p. 307) and the decrease in the individual productivity is rather a consequence of the experienced strain.

For investigating these effects in our model, we differentiate between active-functional and dysfunctional coping. First, active-functional coping (like support-seeking behaviour and searching for solutions or improvements in a stressful situation) is associated with a lower level of exhaustion. In contrast, dysfunctional coping (like displacing reality, escaping behaviour, and the consumption of alcohol or drugs) is related to an increased level of exhaustion; we propose accordingly:

Hypothesis 2a: Active-functional coping is negatively related to employees' level of exhaustion.

Hypothesis 2b: Active-functional coping acts as a moderator, mitigating the negative impact of techno-stressors on exhaustion.

Hypothesis 3a: Dysfunctional coping is positively related to employees' level of exhaustion.

Hypothesis 3b: Dysfunctional coping acts as a moderator reinforcing the negative consequences of techno-stressors on exhaustion.

3.4. Method

3.4.1. Sample

Data for this study was collected within the setting of a larger research project supervised by an interdisciplinary committee from which ethical approval for the survey was obtained. For more information concerning ethics, please see the declaration at the end of this manuscript. Respondents were acquired via an external research panel and paid a small incentive (3.70 USD/3.10 EUR) for participation in the study. Participants gave informed consent, which means they actively agreed that they are over 18 years of age, have read the information on intentions of the research project, ethics and processing of data and data protection by ticking a box. A contact person was listed, and they were informed that they had the possibility to withdraw their consent to participate without giving reasons or disadvantages at any time. Subjects were guaranteed that their answers were collected anonymously as far as possible. "Protecting respondent anonymity and reducing evaluation apprehension" helps to reduce possible common method bias (Podsakoff et al., 2003, p. 888). To do so, we reminded participants that there are no right or wrong answers and that we are interested in their honest opinion at the introduction of each subsection, trying to minimise method bias. While knowledge is a key resource for organisations in the digital age (Attaran et al., 2020), at the same time the majority of knowledge workers have reported to experience stress as a results of the technological changes (Deepa et al., 2015). So, the panellist company was instructed to collect answers from German knowledge workers as these professions seem particularly affected by technostress. Knowledge workers are defined as employees working in an occupation where information is a resource, tool and result of work (Klotz, 1997). Examples for relevant professions are technicians, engineers, scientists, finance, controlling, managers, journalists, consultants, and lawyers. The questionnaire included control variables to test our sample's representativeness, namely age, sex, employment status, occupational title and sector, number of hours worked per week, and education. Further, intensity of technology use for work purposes was assessed. In the first step, the answers of n = 445 participants were collected for a quantitative pre-test of the scales. In a second step, answers for the main study were collected. This final sample consisted of n = 3,362 respondents. Preliminary analysis showed that the distribution of participants according to the control variables age, sex, and sectors (Federal Statistical Office of Germany, 2018a, 2018b) is representative of the German working population. About 46% percent of participants were female and 54% male. The mean age was 42.44 years (*SD* = 11.39). 23% of the participants have a secondary school education, 27% finished a vocational apprenticeship, 19% had a bachelor’s degree, 27% finished with a master’s degree, and 4% percent completed a Ph.D. Most participants (30%) worked in the public or private service sector, followed by 15% who worked in the trade, transport or hotel sector, followed by the producing sector without construction industry (15%), business services industry (14%), information and communication (11%), finance- and insurance services (7%), construction sector (4%), land- and housing sector (2%), and agriculture, forestry and fishing (< 1%).

3.4.2. Measures

We relied on established, validated scales in the survey. All questions were administered in German. If necessary, the items were translated from the original language. Therefore, three German native speakers translated the questions in parallel. They met afterward to resolve discrepancies and agreed on the best translation. In this step, we tried to avoid common method bias which is a potential problem in self-report, for example because individuals like to show consistently in their motives and judgements, they are influenced by implicit theories about the subject of research or they try to present themselves in good light (i.e., social desirability bias) (Podsakoff et al., 2003). However, stress is a highly subjective phenomenon, depending on the individual appraisal and perceptions (Lazarus & Folkman, 1984), so self-report is a common and appropriate tool to assess stress in organisational research if the questionnaire is carefully designed along with a consideration of common-method bias (Razavi, 2001). The following rules were applied to all items in the translation procedure: "keep questions simple, specific, and concise; avoid double-barrelled questions; decompose questions relating to more than one possibility into simpler, more focused questions; and avoid complicated syntax." (Podsakoff et al., 2003, p. 888). The measures were subjected to extensive testing with participants who had not been involved in the research process previously to identify ambiguous terms and to ensure understanding of the translated items. In this quantitative pre-test, the scales' quality was evaluated based on the answers of n = 445 participants. After the pre-test, no changes were made in the translated items. The psychometric properties of the German translation of the scales in the pre-test can be seen in Table 5 in the Appendix.

Complexity, insecurity, invasion, overload, and uncertainty were assessed with the scales developed by Ragu-Nathan et al. (2008). Complexity was measured using five items, for example: "I need a long time to understand and use new technologies". The scale for insecurity encompasses five items, including "I have to constantly update my skills to avoid being replaced." Invasion comprises three items (e.g., "I have to be in touch with my work even during my vacation due to this technology"). Overload was measured with four items. An example is "I am forced by this technology to work with very tight time schedules". Lastly, uncertainty was measured with four items (e.g., "There are constant changes in computer software in our organization"). Additionally, interruptions were assessed with three items published by Galluch et al. (2015), for example, "I experienced many distractions during the task" and finally, unreliability (Ayyagari et al., 2011) was also measured with three items (e.g., "The features provided by digital technologies are dependable"). We used a five-point Likert-type rating scale from 0 = *I do not agree at all* to 4 = *I totally agree* for all items.

Exhaustion was measured with a subscale of the Maslach Burnout Inventory (Maslach & Jackson, 1986). It contains nine items, for example, "I feel emotionally drained by my work". A five-point Likert-type rating scale ranging from 0 = *I do not agree at all* to 4 = *I totally agree* was used.

Productivity was measured with four items (Chen & Karahanna, 2014). It describes self-evaluated work performance (fulfilment of work tasks and general demands). An example item is "I have a reputation in this organization for doing my work very well". Ratings were made on a five-point Likert-type rating scale ranging from 0 = *I do not agree at all* to 4 = *I totally agree*.

Coping was assessed with a selection of 15 items from the Brief COPE (Carver, 1997). We used the existing German translation of the inventory (Knoll et al., 2005). While the original scale contains 28 items paired up in 14 subscales with two items each, the subscales from Prinz et al. (2012) that build on the Brief COPE consist of nine items for active-functional coping and six items for dysfunctional coping. Active-functional coping comprises for example, "I've been taking action to try to make the situation better". An example for dysfunctional coping is "I've been using alcohol or other drugs to make myself feel better". Answers were assessed on a three-point frequency scale ranging from 0 = *never* to 2 = *often*. The items are displayed in Table 7 in the Appendix.

The covariate technology use was assessed with one self-developed item: "How often do you use digital technologies for your work?". Frequency answers were given from 0 = *never* to 4 = *several times a day*.

3.4.3. Means of Analysis

After running descriptive analyses, we subjected the items for the two coping subscales identified by Prinz et al. (2012) to an exploratory factor analysis (EFA) with varimax rotation (see Appendix) to see whether the expected two factors are extracted because the authors of the original scale did not provide this clustering (see Table 6 in the Appendix). The relationships of the variables we propose in our research model were analysed using covariance-based structural equation modelling (Jöreskog, 1970). We utilized the widely used open-source software R and the integrated development environment R-Studio (R Development Core Team, 2019; RStudio Team, 2019). For specific analyses, we used complementary packages in addition to the R base program (i.e., lavaan (Rossel, 2012), psych (Revelle, 2019), GPARotation (Bernaards & Jennrich, 2005), and semTools (Jorgensen et al., 2019)).

To test nonlinear and interactive effects in structural equation models, Kenny and Judd (1984) proposed the product indicator (PI) approach. The products of the observed variables are used as indicators for the latent interaction term in the measurement model. To create the product term, the indicator with the highest reliability should be chosen (Saris et al., 2007), while the product shows optimal reliability as an indicator of the latent interaction variable, whereby the power of the test of the latent moderator increases by an increase in the reliability of the indicator (Saris et al., 2007). When using product indicators, missing independency of higher-order indicators from the lower-level indicators due to the multiplication of the two variables is a problem. Statistical procedures have been introduced to deal with this dependency of higher-order indicators to lower-order indicators. Lin et al. (2010) propose a double mean centring strategy. This approach performs well and eliminates the need for the constraint of the inclusion of a mean structure, as introduced by Jöreskog and Yang (1996). Double mean centring also performs better with non-normal data than (single) mean centring and orthogonalization. It can be combined with different matching strategies of indicators and is available with most commercial SEM software. Hence, to create the indicators for the latent interaction term between techno-stressors and coping, we used the PI approach in which indicators were chosen and matched according to reliability. The product terms were double mean centred (Lin et al., 2010).

3.5. Results

3.5.1. Measurement Models

Preceding the analysis of the proposed relationships in our hypothesis, we tested the measurement models of the endogenous (strain and productivity) and exogenous (job demands and coping) latent variables. Job demands were modelled as a second-order construct (reflected in the seven technology-related stressors) with both first-order and second-order indicators being reflective. For more information about the choice of measurement model please compare Ragu-Nathan et al. (2008, p. 428). The moderated mediation was set up as Hayes (2013) described and based on the in-depth explanations by Stride et al. (2019). Coping moderates the relationship between the independent variable (IV) job demands and the mediator exhaustion (IV–Mediator path) and, further, has a direct effect on exhaustion.

We first assessed means and standard deviations, item reliabilities (loadings), and internal consistency (Cronbach's alpha). Table 1 shows an overview of the scales' properties. For brevity of presentation, the values in the table reflect the final measurement model after deletion of single indicators based on data from the main study (n = 3,362).

Table 1. Descriptive Statistics, Factor Loadings, and Reliability of the Scales in the Study.

Scale	Items	*M*	*SD*	Loadings	α
Complexity	5	1.22	1.04	0.77–0.87	0.91
Insecurity	5	1.23	1.03	0.72–0.82	0.87
Interruptions	3	1.59	1.16	0.85–0.90	0.90
Invasion	3	1.28	1.12	0.64–0.88	0.82
Overload	4	1.62	1.10	0.70–0.85	0.88
Uncertainty	4	1.80	1.04	0.74–0.85	0.87
Unreliability	3	1.82	1.10	0.85–0.92	0.91
Exhaustion	9	1.50	1.09	0.76–0.91	0.96
Productivity	4	2.62	0.85	0.81–0.83	0.89
Active-functional coping (A)	6	0.73	0.60	0.68–0.76	0.86
Dysfunctional coping (D)	4	0.28	0.45	0.62–0.79	0.80

Cronbach's alpha was above 0.70 for all constructs, as recommended (Nunnally & Bernstein, 1994). The test of item reliability showed good results. The factor loadings for each indicator should be above the value of 0.70, indicating that the underlying latent factor accounts for more than 50% of the variance in the respective indicator (Fornell & Larcker, 1981). Most loadings met this threshold. For the items of the two coping constructs and one item of invasion, values below the threshold of 0.70 were observed. The reliability of constructs is evaluated by the average variance extracted (AVE). It determines whether the latent construct accounts for more than 50% of its indicators' variance on average. This threshold was met by invasion and dysfunctional coping, whereas it was below 0.50 for active-functional coping due to very low loadings, even below 0.60. The two items with the lowest loading were removed, which improved the AVE of active-functional coping to 0.51. Further, two items of the latent interaction term between active functional coping and technostress displayed loadings below 0.60. Hence, they were taken out of the model as well.

Internal consistency measures like Cronbach's alpha are not sufficient to imply homogeneity and unidimensionality of constructs (Tavakol & Dennick, 2011). Hence, we additionally analysed the discriminant validity of the latent endogenous constructs with the Fornell-Larcker criterion (Fornell & Larcker, 1981) based on AVE and the correlations among the latent constructs. It is considered as given if the square root of the AVE (printed along the diagonal of the correlation matrix) is higher than the correlations with the other latent variables (off-diagonal elements) (Fornell & Larcker, 1981). The results are displayed in Table 2. All correlations between the latent variables were significant at the level $p < 0.001$. The square root of the AVE printed along the diagonal is higher than the correlations with respective other components for each of the latent factors. This suggests that the discriminant validity of the endogenous constructs in our model is given.

In addition to the procedural remedies which we have taken to avoid common method bias, which is described in the method section, we conducted Harman‘s single factor test (Harman, 1967) to infer whether common method variance that potentially results in common method bias seems to be a problem in our data set. Results of an unrotated principal component analysis to which we subjected all study items show that about 14% is the highest proportion of variance attributed to the first factor. Accordingly, common method variance and, hence, common method bias is not considered a problem.

Table 2. Discriminant Validity According to the Fornell-Larcker Criterion.

Scale	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Complexity (1)	0.82										
Insecurity (2)	0.68	0.76									
Interruptions (3)	0.60	0.54	0.87								
Invasion (4)	0.62	0.72	0.57	0.78							
Overload (5)	0.67	0.71	0.71	0.66	0.81						
Uncertainty (6)	0.43	0.62	0.41	0.50	0.55	0.80					
Unreliability (7)	0.54	0.52	0.63	0.48	0.64	0.44	0.88				
Exhaustion (8)	0.49	0.41	0.50	0.42	0.53	0.21	0.42	0.85			
Productivity (9)	-0.12	-0.02	-0.04	0.02	-0.01	0.11	-0.04	-0.18	0.82		
Active-functional coping (10)	0.19	0.15	0.27	0.14	0.27	0.13	0.26	0.20	0.12	0.71	
Dysfunctional coping (11)	0.49	0.49	0.38	0.50	0.42	0.31	0.34	0.43	-0.02	0.45	0.71

3.5.2. Structural Model

After validating the measurement model, we analysed the structural model to test our hypotheses. Unweighted least squares (ULS) were used as an estimator for the evaluation of the model because ULS perform better with non-normal and ordinal data as they do not make assumptions about the distribution (Forero et al., 2009). Standard errors were obtained through bootstrapping with 1,000 iterations. We tested the models stepwise: First, only the covariate was included, then the IV was added. Next, the mediator variable strain was included and in the last step, we set up the full moderated mediation model. The results are displayed in Table 3.

We assessed the root mean square error of approximation (RMSEA), the square root mean residual (SRMR), the Tucker-Lewis index (TLI), and the comparative fit index (CFI) as indicators of model fit. The χ^2 test statistic is not available with ULS estimation. The absolute fit index RMSEA indicates a good model fit at values smaller than 0.05, just like the SRMR.

CFI and TLI indicate satisfactory model fit greater than 0.95 and a good fit at values above 0.97 (Geiser, 2011). Strict cut-off values were applied to check the model's suitability since it has been shown that in ULS estimations, the indices tend not to detect model–data misfit or misspecifications as efficiently as in maximum likelihood (ML) estimations (Xia & Yang, 2019). Overall, the moderated mediation model showed a good fit. SRMR was 0.05, indicating only a small divergence between the empirically observed and model-implied covariance matrix. RMSEA was 0.05 slightly above the strict threshold of 0.05. CFI and TLI indicate a good fit of the model (both, CFI = 0.98, TLI = 0.98) with values higher than 0.97. Even with the strict cut-off criteria, the model seems to fit the data well. Next, we regarded the regression paths of model 4 to evaluate our hypotheses (cf. Table 8 in the Appendix for standard errors and *z* values of the moderated mediation model). Figure 2 additionally depicts the results.

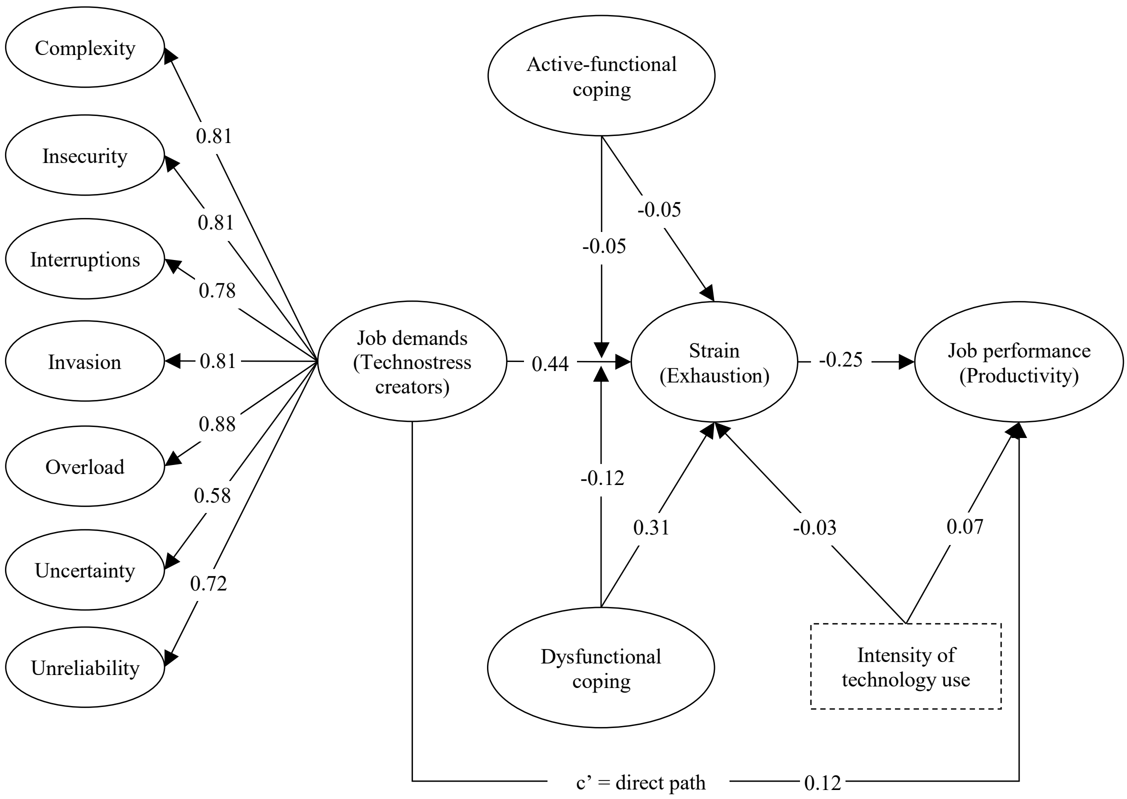

Figure 2. Results of the moderated mediation analysis. Note. Loadings from the items on the first-order constructs are omitted for a better overview of the results. Their range is displayed in Table 1.

Table 3. Results of the Model Estimation: Direct and Moderation Effects.

	Model 1		Model 2		Model 3		Model 4	
	Exhaustion	Productivity	Exhaustion	Productivity	Exhaustion	Productivity	Exhaustion	Productivity
Intensity of technology use	-0.03*	0.08***	-0.03*	0.07***	-0.03*	0.07***	-0.03*	0.07***
Job demands (TS creators)				-0.02	0.57***	0.11***	0.44***	0.12***
Strain (exhaustion)				-0.18***		-0.25***		-0.25***
Active-functional coping (A)							-0.05*	
Dysfunctional coping (D)							-0.05*	
Coping (A) × job demands							-0.05**	
Coping (D) × job demands							-0.12***	
R^2	<0.00	0.01	<0.00	0.03	0.32	0.05	0.36	0.05
ΔR^2	0.00	0.01	0.00	0.02	0.32	0.02	0.04	0.00

Note. Standardised path coefficients are displayed. Bootstrapped standard errors were used for the interpretation of the results. * $p < .05$, ** $p < .01$, *** $p < .001$.

Results of the mediation analysis show that job demands are significantly related to productivity as well as exhaustion. Further, exhaustion is significantly related to productivity. At the same time, the calculated total effect of job demands on productivity $(c = c' + (a \times b))$ was not significant (c = 0.01 (0.03), z = 0.57, p = .568) while the total indirect effect $(ab = a \times b)$ of job demands on productivity via exhaustion was significant (ab = -0.11 (0.02), z = -7.61, $p < .001$). Thus, Hypothesis 1a must be rejected, whereas the results support Hypothesis 1b. Contrary to our expectations, job demands are positively related to job performance and higher productivity. Furthermore, job demands are positively associated with exhaustion as expected and higher levels of exhaustion go along with lower productivity. When both effects are significant but the indirect effect (ab) and the direct effect *c'* point to different directions, we speak of competitive mediation (Xinshu Zhao et al., 2010).

The direct effect of active-functional coping on exhaustion was significant, as well as the direct effect of dysfunctional coping on exhaustion (see Table 3). The results support the assumptions in Hypotheses 2a and 3a. The use of active-functional coping strategies like support-seeking or actively trying to change the stressful situation is associated with lower levels of exhaustion. In contrast, trying to deal with a threatening situation through denial or consumption of alcohol or drugs to overcome negative feelings is associated with higher levels of exhaustion.

Active-functional coping significantly moderates the relationship between job demands and exhaustion. The negative sign of the path coefficient of the latent interaction term indicates that the negative consequences of ICT use are mitigated. The same applies to dysfunctional coping. The sign of the path estimate for the latent interaction term is also negative. Contrarily to our expectations, the use of dysfunctional coping strategies does not reinforce the effect of job demands on exhaustion but buffers it instead (see Table 3). Hence, Hypothesis 2b is supported by the data, whereas Hypothesis 3b must be rejected.

Additionally, indirect effects were calculated based on the path coefficients and low, medium, and high levels of the two moderator variables (*M* ± 1 *SD*). This analysis differentiates between the total indirect and conditional indirect effects (simple slopes for each combination of conditions). The results are displayed in Table 9 in the Appendix. All combinations of low, medium, and high values for each moderator variable point to the same direction. Coping may reduce the detrimental effect of job demands on exhaustion as well as mitigate the negative impact of ICT use on strain. The analyses also show that the effect of dysfunctional coping is larger than the effect of active-functional coping (compare Table 4).

Table 4. Conditional Indirect Effects from the Moderated Mediation Model.

High D (+1 *SD*)	-0.07***	-0.06***	-0.05**
Medium D (*M*)	-0.09***	-0.09***	-0.08***
Low D (–1 *SD*)	-0.12***	-0.11***	-0.10***
	Low A (–1 *SD*)	Medium A (*M*)	High A (+1 *SD*)

Note. Standardised path coefficients are displayed. Bootstrapped standard errors were used for the interpretation of the results of the conditional indirect effects. * $p < .05$, ** $p < .01$, *** $p < .001$.

3.6. Discussion

Our results from the covariance-based structural equation model revealed several unexpected insights. First, besides the negative indirect effect between job demands and productivity (through mediation via exhaustion), there is a positive direct effect. This positive effect means that, with increasing job demands, productivity rises, which intuitively seems contradictory.

This finding is interesting in the light of an ongoing scholarly discussion in IS (Benlian, 2020; Califf et al., 2020; Tarafdar et al., 2019; Tarafdar, Maier, et al., 2020) about eustress and challenge/hindrance stressors (as positive or challenging aspect of stressful encounters (Lazarus & Folkman, 1984)). Challenge is the third kind of stress appraisal in the transactional stress theory (Lazarus & Folkman, 1984). It has much in common with the threat appraisal because it activates coping resources on the one hand, but it also has a motivational aspect on the other hand. It is about the "the potential for gain or growth inherent in an encounter and …[is] characterized by pleasurable emotions such as eagerness, excitement, and exhilaration" (Lazarus & Folkman, 1984, p. 33). For example, if the workload is high, it could motivate a person to work faster and do over hours to earn a good reputation and receive recognition for her/his commitment from the boss. So, the demands could have a challenging effect depending upon the appraisal if the individual sees a chance in the situation.

So, on the one hand, eustress could be an explanation for the positive relation between demands and productivity. On the other hand, the positive relation between demands and exhaustion – which is completely in line with the JD-R theory (Demerouti et al., 2001) – contradicts this presumption. However, it has to be noted that we used a second-order reflective-reflective operationalisation of the construct demands which is in line with prior conceptualisations of technostress (cf. Ragu-Nathan et al., 2008). Opposed to this, research has also shown that effects can or should be viewed in differentiated manner. Results vary in the consideration of single stressors or demands respectively. For example, Califf et al. (2020) contrasted challenge and hindrance stressors: overload, insecurity and unreliability are associated with negative psychological responses and can hence be classified as hindrance stressors, while this association was not given for complexity and uncertainty. Therefore, we think that the conclusion on eustress is nevertheless warranted and the phenomenon needs further investigation which was also called out by Tarafdar et al. (2019).

Another reason for the positive effect of job demands on productivity is a potential suppressor effect, which occurs when the direct and indirect effects on a dependent variable have opposite signs and, therefore, an inconsistent mediation is present (Tzelgov & Henik, 1991). In the literature, it is considered to be realistic that two opposing direct and indirect effects with similar magnitude almost neutralise each other so the total effect is not significant (MacKinnon et al., 2000). Therefore, besides the observed positive relationship between technostress and productivity, an increase in demands may simultaneously lead to a higher level of exhaustion, resulting in lower productivity. Hence, we argue that, despite the positive relationship between job demands and productivity, technostress may lower productivity in a long-term view or have no positive impact on productivity. On the other hand, however, technological job demands increase the strain, leading to long-term health effects and negatively impact organisational objectives from a long-term perspective. Therefore, technostress should be reduced for organisational and human reasons.

Considering the role of coping for overcoming technostress, our results initially confirm prior research regarding the direct effects: a broad application of active-functional strategies is negatively related to exhaustion. In contrast, a broad application of dysfunctional coping may increase it. In doing so, dysfunctional coping exhibits a stronger direct impact on exhaustion. A possible explanation for this could be the nature of active-functional coping: strategies from the active-functional category (such as actively seeking to change the stressful situation) require individuals' energy and cause cognitive effort in implementation, which, in turn, may reduce the buffering effect on exhaustion.

In contrast, surprisingly, both active-functional and dysfunctional coping reduces the relationship between job demands and exhaustion. Furthermore, we even observed considerably higher values for dysfunctional coping regarding the buffering effect on the relationship between job demands and exhaustion. This implies that even though dysfunctional strategies go along with higher exhaustion, their moderating effect on the relationship between job demands and strain is stronger compared to active-functional strategies. This is particularly interesting because dysfunctional coping is said to be detrimental. The consumption of alcohol or drugs, for example, may lead to long-term adverse effects on physical and mental health

(Kahler et al., 2002). Moreover, passive denial of a given situation has been proven to be a concept that is related to the development of depression (Kortte et al., 2003; Naditch et al., 1975) - another reason why dysfunctional coping seems to be a bad strategy to tackle strain. In this context, it is noteworthy that the scale for dysfunctional coping displays a low mean (m = 0.28). The scale includes in its current form aspects that are rather negatively perceived by society like drug or alcohol consumption. Therefore, the low mean could reflect bias in response behaviour pointing at social desirability (Bergen & Labonté, 2020). To our knowledge, there is no research on the interplay between dysfunctional coping and social desirability. This should be considered for future research. Maybe dysfunctional strategies are applied more frequently than we think.

Nevertheless, these dysfunctional coping strategies seem to help reduce the harmful effects of strain resulting from modern technologies in our sample. The reasons for this relationship emerge when the time perspective is taken into account: coping strategies from the dysfunctional category, such as alcohol or denial of the problem, may result in short-term cognitive and emotional relief. From a long-term perspective, however, alcohol consumption naturally leads to other serious health consequences. The low level of content-related involvement with job demands leads to a reduced competence build-up, which ultimately means that resources are not strengthened. Therefore, we argue that dysfunctional coping, despite its short-term positive effects, would reinforce the consequences of demands in the long-term and, thus, should be avoided for efficiently overcoming technostress.

In conclusion, we see in Table 4 that a broad portfolio of coping strategies consisting of both active-functional and dysfunctional coping reduces the indirect negative effect of technostress via strain on productivity and, thus, also the suppressor effect. This implies that employees who use many different coping strategies from both categories would experience less exhaustion, ultimately leading to more productivity due to the additional direct effect of demands. On the other hand, the data shows that employees with generally few different coping strategies can benefit from the suppressor effect as the total effect of the demands on productivity diminishes. However, they are still exposed to the negative consequences in terms of exhaustion. Employees who focus on a broad portfolio in one of the two categories reduce the negative indirect effects of demands on productivity via strain to such an extent that the positive direct effect of demand on productivity potentially remains significant, although the negative health effects - even if in reduced form - should not be neglected. In this context, it is shown that employees who utilize dysfunctional coping strategies can reduce the indirect effect more strongly, resulting in overall higher productivity, while, at the same time, causing more exhaustion than with active-functional coping, which in turn leads to less increase in productivity. The long-term consequences of dysfunctional copying have already been discussed in the previous paragraph.

3.6.1. Theoretical Contribution

Our research provides three important contributions to research on technostress and coping, namely: (1) investigating the influence of technostress and coping on organisational and individual-level outcomes thereby contributing to a current research stream on technostress; (2) modelling coping as a moderator applying the workplace-specific JD-R model as a meta-lens; and (3) emphasize the importance of the distinction between functional and dysfunctional coping of technostress concerning organisational and individual-level outcomes. We will discuss each contribution in detail in die following paragraphs.

In addition to the aspects discussed previously, our research addresses the call by Sarker et al. (2019) that most manuscripts in high-quality journals are concerned merely with the organisational outcomes. In a socio-technical system – i.e., a system focusing on the reciprocal interaction between technology as the technical component and the employee as the social component (Lee et al., 2015; Ryan et al., 2002) - it is important to consider both organisational and individual-level outcomes to create synergies (Griffith et al., 1998; Pava, 1983; Wallace et al., 2004). Therefore, our research addresses the influence of functional and dysfunctional coping on both organisational (productivity) and individual-level outcomes (exhaustion).

Furthermore, in the context of technostress, we have applied the JD-R model as a theoretical meta-lens, in which both organisational and individual-level outcomes play a key role and which has not been applied in this context before (Bondanini et al., 2020). Thus, in comparison to the transactional model of Lazarus and Folkman (1984), which is usually used in the technostress literature, we applied a model that is explicitly focused on the working context. In this, we have also decided to model coping as a moderator, which has also been applied in recently published studies on coping and technostress (Nisafani et al., 2020; Pirkkalainen et al., 2019) and is in line with the JD-R model. Hence, according to our opinion and recent literature, coping can also act as a moderator and have a buffering effect on the relationship between technostress creators and long-term outcomes. This emphasizes the difference to "coping […] as a mediator of short-term emotional reactions" known from Lazarus and Folkman (1987, p. 147).

In addition to modelling coping as a moderator, we also distinguished the specific nature of coping and examined the influence of different coping styles. Thus, we extend recent literature (Nisafani et al., 2020; Pirkkalainen et al., 2019) which focused on a distinction between proactive coping (i.e., strengthening one's ability to cope) - and reactive coping, neglecting the different types of reactive coping. Dysfunctional coping like alcohol or drug consumption as a reactive form of coping has not been thoroughly investigated. For example, addiction in the context of ICT use is most salient in behavioural addiction like consumption of pornography or extensive gaming (Tarafdar, Maier, et al., 2020) while there is less focus on substance abuse. We were able to provide evidence that this aspect should not be neglected in IS research.

Furthermore, we shed light on the role of coping mechanisms used to reduce technostress and, therefore, provide knowledge for the conceptual model of Nisafani et al. (2020) that is in its current form solely covering causal effects of technostress. By doing this, we expand the current knowledge of the existing technostress literature dealing with coping, which is an as-yet less studied research area (Pirkkalainen et al., 2019; Tarafdar et al., 2019).

Overall, technostress research is a highly interdisciplinary field, while it simultaneously is the very essence of IS research community (Sarker et al., 2019). Such plurality of research perspectives is important to create a deeper understanding of emerging threats due to ICT use. Accordingly, this paper brings together psychology and IS research by successfully applying the JD-R model to investigate the relationships between job demands, exhaustion, and productivity and examining the role of coping in the context of ICT use. Within our study, we extend the synthesis of these research fields by particularly meeting the recommendations for further investigating the under-researched role of strategies that individuals deploy to overcome strain caused by ICT used in an occupational setting.

Further, our findings highlight that the ongoing debate in information systems literature regarding the dark or bright side of stress is current and important, in terms of eustress/distress and challenging aspects of ICT use (e.g., Benlian, 2020; Califf et al., 2020; Tarafdar et al., 2019) and equally applies to research on mitigation of technostress.

3.6.2. Practical Implications

Our results provide valuable insights for practitioners who aim to meet technostress efficiently. Therefore, we extend the recently published conceptual model of work-related technostress by Nisafani et al. (2020) by adding active-functional and dysfunctional coping to the list of existing inhibitors, thus addressing the gap mentioned by the authors. In doing this, we support organisations to better deal with the organisational and individual-level outcomes of using ICTs and provide three suggestions, namely: (1) the appropriate level of demands; (2)

the effect of different types of coping strategies; and (3) a categorization of employees with different coping styles.

First, for optimizing employees' job performance, employers should ensure that their employees are exposed to the right level of demands for achieving a high level of productivity. A very low as well as an excessive level of job demands should be avoided. Otherwise, the employee would be under- or overcharged which may result in lower job performance.

Second, regarding coping strategies for meeting technostress, both employees and employers have to carefully deal with the temptations of dysfunctional coping due to the stronger influence on the relationship of job demands and exhaustion: dysfunctional strategies may induce serious consequences in a long-term perspective, e.g., alcohol consumption naturally leading to perceived stress at work as well as negative health consequences due to dependency issues (Anderson, 2012), or behavioural disengagement leading to a higher level of perceived strain (Carver et al., 1989). In this context, employers have to be aware of both their economic as well as social responsibilities: they may increase the support for their employees in applying active-functional coping in order to reduce its effort and, hence, increase the beneficial effects of these strategies in overcoming technostress. Simultaneously, even though dysfunctional coping may seem to be an adequate strategy to overcome technostress, it is crucial to convey the fact that other problems, like addiction, could arise in the long run as well. Employers should be aware of this double-edged sword and take preventive measures to identify individuals with addiction risk. In practice, there are some common measures to identify and support employees with addictive behaviour, e.g., companies and work councils hold regular information events to sensitize both managers and employees to the subject of addiction. Besides, managers should participate in training programmes to provide them with the necessary know-how to identify and support potentially addicted employees. Overall, stakeholders like companies, works councils, managers, employees, company doctors, occupational safety specialists, among others, should ensure this is put to practice and promote appropriate handling of dysfunctional coping.

Third, to reinforce the mitigating effect of coping strategies to overcome technostress, companies should further support their employees regarding their specific coping behaviour: employees who use few different ways of coping should be encouraged to acquire a broader repertoire of various coping strategies for effectively tackling different kinds of stressful situations (cf. Table 4). At the same time, employees who predominantly use one kind of strategy (active-functional or dysfunctional) are recommended to adopt the other category as well and should be supported by their employer in expanding their respective coping behaviour. In this context, it appears highly important to be aware of the long-term health issues of dysfunctional coping, especially if employees often use dysfunctional strategies (predominantly or in combination with active-functional strategies). Hence, employers should ensure to provide know-how regarding these long-term issues by establishing specific health initiatives.

3.6.3. Limitations and Future Research

Besides the provided insights, our study has several limitations that have to be considered. We used a cross-sectional study design to investigate coping as a moderator where the relationships are based on covariance analysis. Thereby, it is important to note that this does not imply causality. We cannot infer whether dysfunctional coping leads to higher exhaustion from the cross-sectional data assessed at one point in time. Causality may just flow the other way round. For example, individuals who feel exhausted might tend to cope with stressful situations in a dysfunctional manner by consuming alcohol, drugs, or behavioural disengagement, respectively. This would mean that dysfunctional coping is not that dysfunctional at all. Besides, we have looked at coping strategies in general instead of actual coping actions to derive broader findings. In doing so, we took Prinz et al. (2012) as a reference and looked at two possible coping strategies - namely active-functional coping and dysfunctional coping. Although we could already derive compelling contributions and implications from this distinction, a differentiated consideration regarding coping strategies could lead to further insights. Finally, we have focused our analyses only on one component of strain - exhaustion. In addition to this, there are further options such as other burnout facets, absence duration, or general health complaints, which may be taken into account.

To summarize, applying the JD-R model within the technostress context by considering coping as moderating the relationship of technostress creators and strain delivers interesting insights contradicting prior results. For future research, we argue that coping as a moderator should be further investigated. Our results extend current knowledge in the IS in terms of coping for overcoming technostress while arguing for further interdisciplinary studies necessary to provide useful knowledge. In doing so, it might be particularly interesting to provide longitudinal and cross-level designs to investigate the effects of dysfunctional coping. The evidence suggests that causality flows in both directions (Hauk et al., 2019). Behavioural disengagement leads to increased strain, and, in turn, a higher level of strain leads to increased behavioural disengagement at a later point in time. Further coping responses are dynamic und users shift from one strategy to another in the process of coping (Salo, Makkonen, & Hekkala, 2020). Hence, it would be interesting to understand coping processes better across time. Furthermore, considering a broader set of different coping strategies could lead to more sophisticated results and enable practitioners to design and support more specific measures to address the negative consequences of ICT use.

Overall, since we successfully put together both IS and psychological stress literature and therefore address the call for further studies proposed by Tarafdar et al. (2019), this paper enriches technostress research regarding the moderating effects of coping strategies and, building on this, further studies which examine coping as moderating the effects of technostress on various outcomes are needed. We actively encourage authors to investigate coping and other mechanism for the mitigation of technostress with longitudinal study designs. This call is of utmost relevance as Benlian (2020) emphasizes that many insights in IS on technostress are solely based on cross-sectional studies.

3.7. References

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3.8. Appendix

Table 5. Scale Properties of the Translated Scales from Ragu-Nathan et al. (2008) in the Pre-Test (n = 445).

Scale	Items	*M*	*SD*	Loadings	α
Complexity	5	1.08	1.21	0.81-0.88	0.93
Insecurity	5	1.04	1.24	0.78-0.88	0.90
Invasion	3	0.98	1.29	0.74-0.90	0.87
Overload	4	1.34	1.35	0.76-0.90	0.92
Uncertainty	4	1.56	1.28	0.78-0.92	0.01

Note. Cronbach's Alpha is quite high, this reflects the higher-order reflective structure that was chosen for data analysis in the latter process within this manuscript. Compare Ragu-Nathan et al. (2008, p. 428).

Table 6. Rotated Component Matrix from Exploratory Factor Analysis of the Two Coping Subscales.

	Factor	
Item	1	2
Brief COPE 2	0.57	
Brief COPE 3		0.67
Brief COPE 4		0.74
Brief COPE 5	0.58	
Brief COPE 7	0.72	
Brief COPE 8		0.59
Brief COPE 10	0.72	
Brief COPE 11		0.75
Brief COPE 13	0.49	0.48
Brief COPE 14	0.75	
Brief COPE 15	0.62	
Brief COPE 21	0.53	0.41
Brief COPE 23	0.67	
Brief COPE 25	0.65	
Brief COPE 26	0.41	0.53

Note. Results of a principal axis factoring with varimax rotation. Number of factors was determined through parallel criterium. Factor loadings < .35 are not printed. Cross-loadings are in boldface, these items were excluded for the analysis of the measurement and the structural model.

Table 7. Items of the Coping Scales: Wording, Descriptive Statistics, and Factor Loadings.

	M	*SD*	Loading
Active-functional coping			
Brief COPE 7: I've been taking action to try to make the situation better.	0.88	0.84	0.70
Brief COPE 10: I've been getting help and advice from other people.	0.76	0.77	0.76
Brief COPE 14: I've been trying to come up with a strategy about what to do.	0.86	0.84	0.72
Brief COPE 15: I've been getting comfort and understanding from someone.	0.50	0.69	0.70
Brief COPE 23: I've been trying to get advice or help from other people about what to do.	0.63	0.73	0.72
Brief COPE 25: I've been thinking hard about what steps to take.	0.69	0.84	0.68
Dysfunctional coping			
Brief COPE 3: I've been saying to myself "this isn't real".	0.34	0.61	0.69
Brief COPE 4: I've been using alcohol or other drugs to make myself feel better.	0.24	0.54	0.77
Brief COPE 8: I've been refusing to believe that it has happened.	0.34	0.59	0.63
Brief COPE 11: I've been using alcohol or other drugs to help me get through it.	0.22	0.53	0.79

Note. Items which were excluded during the analysis of the measurement model are omitted. Factor loadings were obtained from confirmatory factor analysis in SEM.

Table 8. Detailed Results of the Moderated-Mediation Model.

	Productivity			Exhaustion		
Predictor	*Est*	*SE*	*z*[a]	*Est*	*SE*	*z*[a]
Job demands	-0.12***	0.04	4.19	0.44***	0.06	14.64
Exhaustion	-0.25***	0.02	-9.22			
Active-functional coping (A)				-0.05*	0.05	-2.25
Dysfunctional coping (D)				0.31***	0.09	8.10
Coping (A) × job demands				-0.05**	0.03	-2.61
Coping (D) × job demands				-0.12***	0.06	-4.85
R^2		0.05			0.36	

Note. Standardised path coefficients are displayed. [a] Bootstrapped standard errors were used for the interpretation of the results. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 9. Conditional Indirect Effects from the Moderated Mediation Model.

Moderator values		Indirect effect		
A	D	*Est*	*SE*	z^a
Low A (–1 *SD*)	Low D (–1 *SD*)	-0.12***	0.02	-8.22
Medium A (*M*)	Low D (–1 *SD*)	-0.11***	0.02	-8.04
High A (+1 *SD*)	Low D (–1 *SD*)	-0.10***	0.02	-7.58
Low A (–1 *SD*)	Medium D (*M*)	-0.09***	0.02	-6.80
Medium A (*M*)	Medium D (*M*)	-0.09***	0.02	-6.51
High A (+1 *SD*)	Medium D (*M*)	-0.08***	0.02	-5.96
Low A (–1 *SD*)	High D (+1 *SD*)	-0.07***	0.02	-3.93
Medium A (*M*)	High D (+1 *SD*)	-0.06***	0.02	-3.58
High A (+1 *SD*)	High D (+1 *SD*)	-0.05**	0.02	-3.13

Note. Standardised path coefficients are displayed. [a] Bootstrapped standard errors were used for the interpretation of the results of the indirect effects. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 10. Constructs and Scales Used in the Study: Item Wording and Sources.

Construct	Item	Source
Active-functional coping	I've been taking action to try to make the situation better.	Original: Carver (1997)
	I've been getting help and advice from other people.	Translation by Knoll et al. (2005)
	I've been trying to come up with a strategy about what to do.	Items subscale: Prinz et al. (2012)
	I've been getting comfort and understanding from someone.	
	I've been trying to get advice or help from other people about what to do.	
	I've been thinking hard about what steps to take.	
Dysfunctional coping	I've been saying to myself "this isn't real".	Original: Carver (1997)
	I've been using alcohol or other drugs to make myself feel better.	Translation by Knoll et al. (2005)
	I've been refusing to believe that it has happened.	Items subscale: Prinz et al. (2012)
	I've been using alcohol or other drugs to help me get through it.	

Construct	Item	Source
Job demands: Complexity	I do not know enough about this technology to handle my job satisfactorily.	Ragu-Nathan et al. (2008)
	I need a long time to understand and use new technologies.	
	I do not find enough time to study and upgrade my technology skills.	
	I find new recruits to this organization know more about computer technology than I do.	
	I often find it too complex for me to understand and use new technologies.	
Job demands: Insecurity	I feel constant threat to my job security due to new technologies.	Ragu-Nathan et al. (2008)
	I have to constantly update my skills to avoid being replaced.	
	I am threatened by coworkers with newer technology skills.	
	I do not share my knowledge with my coworkers for fear of being replaced.	
	I feel there is less sharing of knowledge among coworkers	
Job demands: Invasion	I have to be in touch with my work even during my vacation due to this technology.	Ragu-Nathan et al. (2008)
	I have to sacrifice my vacation and weekend time to keep current on new technologies.	
	I feel my personal life is being invaded by this technology.	
Job demands: Overload	I am forced by this technology to do more work than I can handle.	Ragu-Nathan et al. (2008)
	I am forced by this technology to work with very tight time schedules.	
	I am forced to change my work habits to adapt to new technologies.	
	I have a higher workload because of increased technology complexity.	

Construct	Item	Source
Job demands: Uncertainty	There are constant changes in computer software in our organization.	Ragu-Nathan et al. (2008)
	There are constant changes in computer hardware in our organization.	
	There are frequent upgrades in computer networks in our organization.	
	There are always new developments in the technologies we use in our organization.	
Job demands: Unreliability	I often experience that features provided by digital technologies are not dependable.	Adapted from Ayyagari et al. (2011)
	I often experience that the capabilities provided by digital technologies are not reliable.	
	I often experience that digital technologies do not behave in a highly consistent way.	
Job demands: interruptions	I received too many interruptions during the task through digital technologies.	Adapted from Galluch et al. (2015)
	I experienced many distractions during the task due to digital technologies.	
	The interruptions caused by digital technologies are frequent.	
Exhaustion	I feel emotionally drained by my work.	Adapted from Maslach and Jackson (1981)
	Working at my job all day long requires a great deal of effort.	
	I feel like my work is breaking me down.	
	I feel frustrated with my work.	
	I feel I work too hard on my job.	
	It stresses me too much to work on my job.	
	I feel like I am at the end of my rope.	
	I feel burned out from my work.	
	I feel used up at the end of the workday.	
Productivity	I am viewed by my supervisor as an exceptional performer.	Chen and Karahanna (2014)
	I am viewed as an exceptional performer in this organization.	
	I have a reputation in this organization for doing my work very well.	
	My colleagues think my work is outstanding.	

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3.8.2. Disclosure of Interest

The authors report no conflict of interest.

3.8.3. Data Availability Statement

The data that support the findings of this study are currently not publicly available due to restrictions during the runtime of project. After the completion of the project and an appropriate time of embargo, it will be made publicly available in the database on occupational safety and health research of the Federal Institute for Occupational Safety and Health.

3.8.4. Ethics Declaration

Ethical approval was obtained from the German Association for Experimental Economic Research e. V. (Institutional Review Board Certificate No. Hr2gRktW) In addition, the project partners are supported in the implementation of PräDiTec by experts from an interdisciplinary advisory board who provide technical, work-organizational, ethical, and legal counselling and belong to the following organizations:

- Works Council Academy Bavaria (BAB)
- Confederation of German Employers' Associations (BDA)
- German Trade Union Confederation (DGB)
- Research Centre for E-Health Law at the University of Augsburg
- Chair of Moral Theology at the University of Augsburg
- Administrative Trade Association (VBG)
- Centre for Interdisciplinary Health Research at the University of Augsburg

4. Extending the Concept of Technostress: The Hierarchical Structure of Digital Stress

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Abstract:

The increasing use of digital technologies at the workplace has led to the emergence of a specific form of stress: technostress. Research conceptualizing technostress dates to over a decade ago. Given that digital technologies are now present in unprecedented variety, pervasiveness, and usage intensity, the question arises whether the current technostress concept is still up to date. To answer this question, we designed a sequential qualitative-quantitative mixed-methods study. Key results are as follows: Based on theoretical reasoning and empirical data, we present a holistic framework of twelve demands from work practices relating to digital technology use and present a valid and reliable survey-based measurement model to assess the demands. The twelve demands integrate nine demands described as technostress creators and related concepts in previous literature, as well as three newly identified demands. Our data suggest a hierarchical structure with four second-order factors underlying the demands. Further, we embed the hierarchical model of demands in a nomological net that reveals work- and health-related effects. Given the magnitude of change regarding the considered stress creators and the context of digital transformation, we suggest the concept of "digital stress" as an updated extension of technostress.

Keywords: Technostress, digital stress, digital work, demands, multilevel structure, mixed-methods

4.1. Introduction

Recent sociotechnical developments caused by ongoing digitalization (e.g., artificial intelligence, robotic process automation, anthropomorphic systems) have dramatically changed the work environment and culture. The COVID-19-pandemic has further intensified this change by necessitating an increasing amount of virtual collaborations and employees working remotely. Digital and smart workplace technologies are facilitating business processes and providing efficient communication and collaboration tools, "increasing the productivity of the workforce in the information age" (Attaran et al., 2019, p. 1).

However, the use of digital technologies also significant downsides: for example, information flows across many different channels, frequent interruptions, and blurred boundaries between work and private life (Tarafdar et al., 2010). Such demands may cause a specific form of stress, identified already in the 1980s when Brod (1982, 1984) coined the term technostress to describe the human cost of the computer revolution. However, the intensity of use and diversity of digital technologies and virtual collaboration available in the business context has changed dramatically since the 1980s. The contemporary perspective of technostress was shaped more than two decades later by seminal papers such as Tarafdar et al. (2007), Ragu-Nathan et al. (2008), and Ayyagari et al. (2011). The core-framework centers on a misfit of demands arising from digital technology use and a person's resources to cope with these demands. Many consider the five technostress creators introduced by Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) to be the standard concept of technostress (e.g., Benlian, 2020; Califf et al., 2020). Although these papers also identify the bright sides of IT use, including productive challenges, high performance, learning, personal growth, and positive emotions (Benlian, 2020; Califf et al., 2020; Tarafdar et al., 2019), we focus on the dark side of technostress in this paper.

IT use behavior necessitates the investigation of technostress. Tarafdar et al. (2007, p. 304) suggested that "given the proliferation of ICTs in the workplace in recent years, there are a number of ways in which their use can create stress for people using them." Likewise, Ayyagari et al. (2011, p. 831) stated that "with the proliferation and ubiquity of information and communication technologies, it is becoming imperative for individuals to constantly engage with these technologies in order to get work accomplished." About a decade later than the seminal works shaping our understanding of technostress, Fischer et al. (2019, p. 1822) argued that they "see no reason why this development would have stopped."

Ragu-Nathan et al.'s (2008) paper was first submitted to *Information Systems Research* in July 2005; however, the data was acquired earlier. At that point in time, IT-enabled work was shaped by a wide diffusion of PCs and the Internet. However, Facebook was only a year old and social computing was in its infancy, with the term Web 2.0 becoming popular by the end of 2005. Google's CEO first used the term "cloud computing" in August 2006 (Regalado, 2011) and mobile computing began to emerge in 2007 with the release of the first iPhone. Work and IT use for work have arguably changed substantially since these times. Technologies related to social, mobile, analytics, cloud, and the internet of things – summarized in the popular SMACIT acronym (Sebastian et al., 2017) – are now widely available at workplaces. Further, some workplaces feature the use of artificial intelligence, augmented and virtual reality, 3D printing and other advanced digital technologies. These digital technologies do not merely represent the world, they shape our world and lead to fundamental changes at work (Baskerville et al., 2020).

Tarafdar et al. (2019, p. 7) recently argued that technostress is a "continually evolving phenomenon as new types of IS … and their use persistently emerge and reveal novel aspects of it." Similarly, La Torre et al. (2019) stated that the definition of technostress has changed over time. Tarafdar et al. (2019) acknowledged this dynamism by updating their core-conceptualization of technostress by assigning new dimensions to known technostress creators.

This dynamism of technostress concepts can be seen, for example, in a literature study on technostress conducted by Nisafani et al. (2020), who found indications for additional technostress creators, which, however, refer less to the technology itself than how it is handled and users' expectations (e.g., role ambiguity, flexibility). However, Fischer et al. (2019) remarked that it is disputable whether new aspects can simply be added to a small set of known technostress creators (e.g., techno-invasion, techno-insecurity) or whether additional dimensions are needed. This debate raises the question of whether the present concept of "technostress" is still up to date and accounts for the prevailing circumstances, with digital technologies having reached an unprecedented variety, pervasiveness, and usage intensity in all domains of life.

Contemporary research in the field of technostress deals with topics such as stress appraisal (e.g., Benlian, 2020; Califf et al., 2020), stress coping (e.g., Pirkkalainen et al., 2019; Tarafdar et al., 2020), stress outcomes (e.g., Chen et al., 2019; La Torre et al., 2020), and the design of stress-sensitive systems (e.g., Adam et al., 2017; Jimenez & Bregenzer, 2018). These research foci are valuable and essential since it is the appraisal of technostress creators and the application of coping measures that determine the extent to which employees experience technostress and its negative consequences. At the same time, however, it is also crucial to examine how working life has changed and how this change affects technostress creators, their perception by employees, and appropriate prevention and coping measures. Only an up-to-date understanding of digital work demands that create stress will allow researchers to study the appraisal, coping, outcomes, and system design concerning these demands.

Therefore, a conceptualization of stress caused by digital technology use that fits the new sociotechnical context of digital work is important for understanding the resulting psychological strain and its organizational and personal consequences (e.g., low productivity, dissatisfaction at work, health issues) and to allow researchers and practitioners to design and analyze measures to counter this dark side of digital transformation. We do not suggest that an entirely new theory of technostress is needed. However, context matters for theories (Hong et al., 2014), and the digital transformation (Vial, 2019) has changed the technological, organizational, and social context of work for many individuals. We believe the time has come to update technostress theory. Toward this end, we adopt a cumulative knowledge perspective, and pose the following research questions:

RQ1: Which demands from contemporary work practices relating to digital technologies cause stress for employees?

RQ2: How do these different demands relate to each other?

To answer these research questions, we applied a sequential qualitative-quantitative mixed-methods research design. For this, we followed the guidelines by Venkatesh et al. (2013) and Venkatesh et al. (2016). Our research is divided into a qualitative phase grounding our research in a general conceptual framework relying on expert interviews and focus group discussions, followed by a quantitative phase analyzing survey data from overall 5,005 employees.

Key contributions are as follows: First, we present a holistic framework of twelve contemporary digital work demands, summarizing demands spread across different studies and adding new demands. Second, based on theoretical and empirical evidence, we model the hierarchical structure of these demands. Third, given the magnitude of change related to the considered stress creators and the context of digitalization, we propose the concept of "digital stress" as an update to and extension of technostress. Fourth, we present and validate a survey-based measurement model for the complete set of demands.

In the following section, we describe the conceptual foundation and current state of knowledge. Our mixed-methods research process and related design decisions are explained in Section 3. Section 4 presents the qualitative phase of our research and focuses on the conceptual development of stress induced by digital technologies. Section 5 introduces the quantitative phase and presents the survey results. Section 6 discusses the results and the meta-inferences, and Section 7 concludes the paper.

4.2. Conceptual Foundation

Brod (1984, p. 16) describes technostress as “a modern disease of adaptation caused by an inability to cope with the new computer technologies in a healthy manner”, illuminating the phenomenon from an early perspective. The scholarly concept from Tarafdar et al. (2007, p. 304) specifically focuses on the workplace, stating that “in the organizational context, technostress is caused by individuals' attempts and struggles to deal with constantly evolving [information and communication technologies] and the changing physical, social, and cognitive requirements related to their use.” These definitions stem from different decades and contexts but, importantly, they are both based on the transactional theory of stress. According to this theory, stress is more than a threatening, potentially harmful event and entails more than the individual’s response to a stressor. Stress is neither anchored solely in the environment nor in the person; it is created in a transactional process (Lazarus & Folkman, 1984). Demands are transmitted from the environment to a person through appraisal, which signifies the validation of situational facets, “with respect to the significance for well-being” (Lazarus & Folkman, 1984, p. 31), along with one’s resources and ability to handle this situation.

Following Lazarus and Folkman (1984), technostress arises when negative consequences resulting from digital technology use are anticipated and an imbalance occurs between these demands, and the user's personal or organizational resources to meet the demands (Tarafdar et al., 2007). Digital technologies exist in various forms and refer to a “combinations of information, computing, communication, and connectivity technologies” (Bharadwaj et al., 2013, p. 471). By using these new technologies in a working context, work becomes more digital. We define digital work as „effort to create digital goods or that makes substantial use of digital tools” (Durward et al., 2016, p. 283). While further definitions propose a broad perspective in which current work practices always entail digital aspects (Orlikowski & Scott, 2016), we view digital work as essentially knowledge work in the framework of this study (Nash et al., 2018).

In their recent literature analysis of existing work on technostress, Tarafdar et al. (2007) structured existing research on technostress along with a framework that builds on the transactional process. This framework includes technology environmental conditions, technostress creators, consequences, and moderators of the technostress creators and outcomes relationship. Our focus here is on technostress creators, which are specific demanding conditions that occur during digital technology use and must be met using personal resources. Techno-invasion, techno-overload, techno-complexity, techno-uncertainty, and techno-insecurity are well-known technostress creators (Ragu-Nathan et al., 2008; Tarafdar et al., 2007). Techno-invasion refers to situations that require being constantly available and connected, which may cause the boundary between work and private life to blur. Techno-overload is associated with situations in which digital technologies induce a greater workload and higher speed of work. Techno-complexity describes situations where digital technologies make users feel that they lack the skills and experiences necessary to deal with the complexities of digital technologies and are forced to spend time and effort learning about them. Techno-uncertainty refers to situations in which digital technologies are frequently changed and upgraded, requiring users to continually develop their abilities and knowledge. Techno-insecurity describes situations where users perceive the threat of losing their job due to automation or the lack of skills needed to deal with digital technologies.

The five well-established technostress creators introduced by Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) have attracted much attention in the research on technostress and are still considered to be state-of-the-art conceptualizations of technostress. Califf et al. (2020, p. 812) state that “in IS research, technostress is composed of five dimensions” and Benlian

(2020, p. 1264) refers to them as "classical technostress creators." Many other recent studies also refer to these technostress creators (e.g., Güğerçin, 2020; Korzynski et al., 2021; Molino et al., 2020; Pflügner et al., 2020; Pflügner et al., 2021). However, other aspects discussed in the literature are also capable of creating technostress and can cause negative consequences for individuals using technologies at the workplace.

Fischer and Riedl (2015) and Adam et al. (2017) for example, discuss techno-unreliability. This technology-related stressor comprises system malfunctions as well as IT hassles. Galluch et al. (2015) focus on interruptions enabled by digital technology, such as emails and instant messages. Ayyagari et al. (2011) consider role ambiguity and the invasion of privacy to be part of the technostress concept. Role ambiguity describes the unpredictable consequences emerging from the conflict between the need to perform a role and the lack of information to adequately do so. This might occur, for example, when an employee is unsure whether to prioritize dealing with technical problems or work activities. Invasion of privacy involves the perceived impairment of one's privacy. Invasion of privacy is not to be confused with techno-invasion. While techno-invasion focuses on the blurring of boundaries between work and private life, invasion of privacy refers to the perception that the private and occupational use of digital technologies during work time can easily be traced, potentially allowing the employer or coworkers to invade one's privacy.

4.3. Research Process

We followed a mixed-methods design. Mixed-methods research designs "contain elements of both quantitative and qualitative approaches" (Tashakkori & Teddlie, p. 5). Within the IS discipline, mixed-methods designs are beneficial since context changes frequently and researchers may have difficulty drawing significant insights from existing theories and perspectives (Venkatesh et al., 2013) Mixed-methods designs offer three specific benefits: the ability to "address confirmatory and explanatory research questions," to "provide stronger inferences than a single method or worldview," and to "produce a greater assortment of divergent and/or complementary views" (Venkatesh et al., 2016, p. 437). Given the general multiplicity of studies on technostress and the changed context, a mixed-methods design is well suited to our work.

Our study's mixed-methods design began with the articulation of two research questions. We followed a developmental purpose, first conducting a qualitative study and then using the results from this study to develop the research model tested in the second quantitative phase of research (Tashakkori & Teddlie; Venkatesh et al., 2013; Venkatesh et al., 2016). We adopted multiple paradigms as an epistemological stance. During the qualitative phase (Phase 1), we take an interpretive perspective. During the quantitative phase (Phase 2), we adopted a positivist approach. This methodology can be classified as "mixed-methods multistrand" approach (Venkatesh et al., 2016, p. 443), with both strands of research being equally important. We used a sequential sampling strategy with parallel samples and performed data analysis sequentially to help build the research model for the quantitative study based on the results of the qualitative study (Venkatesh et al., 2016).

Overall, the mixed-methods design is divided into two phases (see Figure 1). In the qualitative phase, we accomplished the following: We grounded our research in a general conceptual framework and compiled known demands of digital work discussed in this literature to provide a holistic view of stress and technostress (Phase 1a). Subsequently, we revealed new digital work demands through interviews with experts from various fields and through focus group discussions. By identifying the currently most important/significant stressful aspects of the interaction with digital technologies, we were able to understand the conditions that may give rise to technostress (Phase 1b). We concluded this phase with qualitative inferences by analyzing the interview data and iteratively reviewing the literature base. We thus defined the demands and evaluated the concept of technostress to understand whether it complies in its current form with the (newly) defined technostress creators (Phase 1c). Phase 1 was influenced by contextual research studies (see Hong et al., 2014). While the first three steps of the guideline Hong et al. (2014) can be mapped to Phases 1a-c, Steps 4-6 of the guideline by are not reflected in our research process because Phase 2 of our study goes beyond contextualizing. The overarching goal of this research is the extension of theory.

In our quantitative study, we accomplished the following: We operationalized the constructs and pre-tested our measurement model (Phase 2a). We used validated scales from literature where possible and developed items for newly identified demands that emerged from the qualitative study. We examined the associated measurement models, and then drew on survey data to validate our measurement model and thereby the findings from the qualitative study. Further, we revealed higher-order structures to understand the multilevel structure of the demands (Phase 2b). We then selected the best structure for the demands based on another survey and embedded the model in a nomological net to test its validity (Phase 2c). We concluded our mixed-methods study by integrating the findings from the qualitative and quantitative phases of our research and deriving meta-inferences.

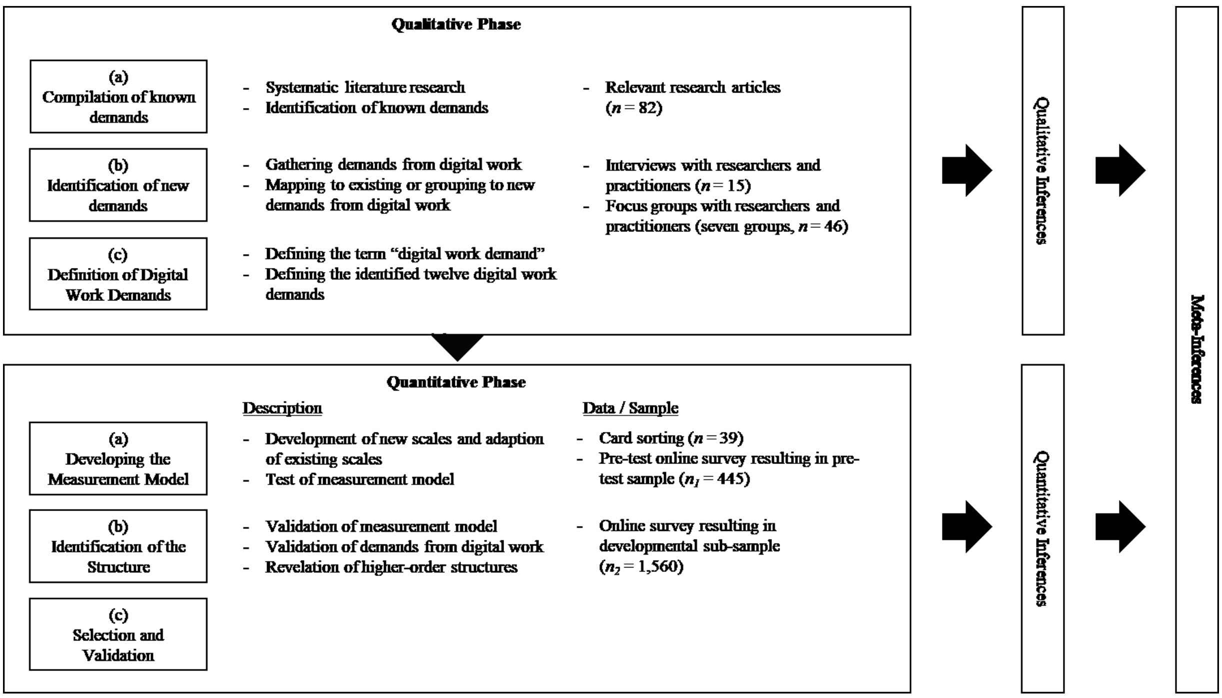

Figure 1. Research Process of the Mixed-Methods Research Paradigm.

4.4. Qualitative Phase

4.4.1. Compilation of Known Demands

In the literature building our research foundation, we aimed to identify phenomena classified as technostress creators. We searched the following databases: EBSCO Business Source Premier, EBSCO Academic Search Premier, EBSCO Psych, Web of Science, and PubMed. Because the seminal paper on this topic by Tarafdar et al. was published in 2007, we included only publications from this year onward. Types of publications that we considered included academic journals, proceedings, books, book chapters, and dissertations. First, we developed several search strings for aspects, potentially linked to technostress. These included technologies, the occupational context, as well as different possible outcomes such as stress and strain, detachment, monitoring, cognition, acceptance, and job performance. We then combined the search strings for technologies and the context, including only one specific outcome at a time.

Overall, 82 articles were identified as relevant because their title and/or abstract are directly linked to technologically induced stress at work. The final list covered a broad range of literature from several disciplines—most importantly, from information systems, psychology, and media science. From this corpus, we extracted the constructs capturing technologically induced stress and analyzed their definitions and operationalizations. This process led to the identification of the nine technostress creators covered in the Conceptual Foundation Section above: techno-invasion, techno-overload, techno-complexity, techno-uncertainty, techno-insecurity, techno-unreliability, interruptions, role ambiguity, and invasion of privacy.

4.4.2. Identification of New Demands

We collected qualitative data from expert interviews and focus groups to gather information about potential new technostress creators not yet covered in the technostress literature. Both interviews and focus groups are commonly used for in-depth analysis of a phenomenon. While interviews are often conducted with the goal of obtaining individual expertise on a specific topic, focus groups are more appropriate for research questions investigating how certain issues are talked about or debated (Secor, 2010). Therefore, we conducted expert interviews and one expert focus group to gain insights from a broader and more general practical perspective. Employee focus groups were held to receive information from employees affected by technostress in their everyday working lives.

The interview participants came from both science and practice to cover a variety of perspectives. We conducted 15 semistructured interviews with experts having backgrounds ranging from employer and employee representation, corporate health management, occupational science, computer science, human resources, and moral ethics. Table 1 shows a list of all interviewed experts. All interviews were recorded and transcribed.

Table 1. List of Experts and their Function.

Code	Role
Exp1	Chairman of the works council working for a manufacturer of entertainment and communication technology with over 2,000 employees
Exp2	Employee of the human resources department working for a manufacturer of entertainment and communication technology with over 2,000 employees
Exp3	Head of human resources department in a SME focusing on customer acquisition and retention
Exp4	Person in charge of occupational reintegration management in a SME focusing on customer acquisition and retention
Exp5	Chairman of the works council working in a SME focusing on customer acquisition and retention
Exp6	Scientific director of a federal institute focusing on occupational safety and health
Exp7	Researcher with a focus in working-time and work organization at a federal institute focusing on occupational safety and health
Exp8	University professor for moral ethics
Exp9	Work health and safety expert from a major employer association
Exp10	Former vice-chairman of the works council and lecturer at a training institute for works councils
Exp11	University professor for sociology
Exp12	Software developer at a university IT department
Exp13	Head of competence field occupational safety working for an occupational health management service provider responsible for over one million employees
Exp14	Regional director working for an occupational health management service provider responsible for over one million employees
Exp15	Regional director working for an occupational health management service provider responsible for over one million employees

The expert focus group consisted of researchers from computer science, information systems, and psychology. The employee focus groups consisted of different occupational groups, with separate groups for executive staff and employees. In total, we conducted seven practitioner focus groups and two researcher focus groups with five to eight participants per group. An overview of all focus groups can be found in Table 2. In total, 61 individuals took part in the qualitative data collection, 15 in individual interviews and 46 in focus groups. There were 27 male and 19 female participants who took part in the focus group workshops, with ages ranging from 25 to 64 years. Two facilitators conducted the focus groups; they took field notes and recorded the results from the discussions.

Table 2. Overview of the Participants from the Focus Groups.

Focus Group	**Number of Participants**	**Level of Hierarchy**	**Occupational Group**
1	6	Staff	Controlling, human resource, marketing, product manager
2	8	Staff	IT support, account manager, media designer/production, business development, tourism
3	7	Staff	Counseling, psychologist, doctors, distribution
4	5	Executive staff	Distribution, IT
5	6	Department managers	IT, marketing, quality management, finance, supply chain management
6	6	Postdoctoral and doctoral researchers	Researchers in information systems
7	8	Professors	Researchers in information systems, computer science, and psychology

The basic structure of both the expert interviews and focus groups was similar: first, the participants were asked to list the technologies they currently use for work. In the focus groups, we asked the participants to rate how much the use of each single technology stresses them out on a scale ranging from not at all to completely. This step was omitted in the expert interviews. The purpose was to narrow down the list of relevant technologies having a high potential for stress. Afterwards, we asked participants to name the potential aspects (characteristics and use cases) of these technologies that cause stress. Here, we deliberately avoided the term technostress to retrieve general experiences in handling digital technologies, which we expanded using a question about the resulting consequences of the encountered stress for employees. To complete the picture, attendees elaborated on how they might successfully overcome (i.e., cope with) the stress.

We used a qualitative deductive approach to analyze transcripts and field notes (Pearse, 2019). At first, we developed a codebook based on our previously conducted literature review. For the nine technostress creators derived from the literature, we created codes for sources of the respective technostress creators, consequences resulting from these sources, coping behaviors, and resources that might be used to prevent technostress caused by the specific technostress creator. Furthermore, we subdivided the codes for sources and resources into technological, organizational, and individual types of origin. Subcodes for consequences were divided into physiological, cognitive, and behavioral consequences, whereas coping strategies were coded separately as problem-oriented and emotion-oriented strategies. Beyond this, a general code with the same subcodes mentioned above was created for topics not related to one of the technostress creators identified in the literature. The codebook was then applied to the analysis of the collected data to identify themes. Themes can be described as patterns within the data (Braun & Clarke, 2006), and may derive from codes that either existed in the original codebook or were added afterward through the analysis process (Pearse, 2019). Our primary focus was on those themes that could not be linked to one of the technostress creators named in the literature so that we could identify potentially new/understudied technostress creators.

Overall, the interviews and focus groups revealed three recurring themes not linked to established technostress creators. The first theme emphasizes the potential monitoring of employees enabled by newly arising digital technologies. Concerning this theme, one member of a work council (Exp1) stated[6]:

[6] All quotes have been translated into English by the authors.

"To some degree, our production line is close to industry 4.0. For almost 20 years now, we record and process data. That´s why we can assign which employee produced a device on any given day in the past in case, for example, a client complains about a defective one. For us, this is absolute monitoring of employees. In this regard, employees have to be protected so that the new possibilities won't lead to surveillance. This is a common topic for us. Once employers have the possibility to monitor employees even a little bit, we try to prevent them from doing so. And most of the new technologies can easily be used for monitoring employees."

However, monitoring not only allows employees to be blamed for possible mistakes made in the past, but new technologies also allow for performance comparisons among employees. As one employee representative (Exp10) explained:

"Regarding digital stress, one common question is related to new possibilities of monitoring. A lot of new technologies and forms of work, like, for example, working in a cloud or crowd, offer new possibilities of usability, interpretability, and comparability. A one-sided transparency, as I call it. This doesn´t even have to be strict efficiency control. However, one does become more visible. This is an important point."

The second theme, which was reoccurring and not related to the technostress creators identified in previous literature, emphasizes a certain nonavailability of modern technologies. In this regard, a leading scientist at a federal institute focusing on occupational safety and health (Exp6), mentioned:

"[…] one can name a restrictive use of access rights as well as a more general access to technologies. That you cannot work as you want or the situation requires because of organizational regulations."

The knowledge that technologies exist to make one's work easier but are not available for use can lead to perceived stress. A professor for moral ethics (Exp8) summarized these situations as follows:

"I notice a tendency towards anachronism. From my perspective as a professor, I have to correct exams and write reports handwritten. You ask yourself: 'What year are we living in?'. So much additional effort just because you are not allowed to work with digital technologies. This definitely leads to stress. This is ridiculous. As a workaround, I write everything with my computer, print my comments as etiquettes and glue these into the exams. Until now, no one did complain about it. In some domains, especially if regulated by the state, you have to work in ways, which do not fit into our modern times. This waste of time causes stress."

Participants in focus groups also mentioned this theme. When asked about potential stress creators, most participants mentioned inadequate software design, insufficient personal competence, or the unreliability of the technologies they use as the most frequently occurring stress creators caused by technology. These themes are common within technostress literature. However, some participants in different focus groups mentioned a lack of access rights as well as the nonavailability of necessary technologies as a source of stress.

The third theme that presented was that employees often lack a sense of achievement when working with digital technologies. This phenomenon was mentioned in the seventh focus group when discussing potential creators of stress. In the discussion, one of the attendees, a computer science professor, mentioned the difficulty of feeling a sense of progress or achievement when working with digital technologies, describing it as a sense of not seeing the results of one's work—contrasted, for example, with the clear physical results craftspeople see in their work. The attendee cited this as a problem that he personally experienced. Indeed, his research focuses on designing technologies to address this problem. After some discussion about this, the focus group concluded by suggesting that lacking a sense of achievement could be described as another digital work demand in addition to the ones already mentioned in the literature.

4.4.3. Definition of Digital Work Demands

Technostress literature refers to multiple technostress creators or techno-stressors (Tarafdar et al., 2007; Tarafdar et al., 2019). Strictly speaking, these are potential technostress creators or potential techno-stressors because whether these circumstances (like techno-invasion) lead to stress depends on the individual and the individual's appraisal in a specific situation. For example, whether an unreliable technology is seen as a technostress creator results in part from the individual analysis of the work situation. Benlian (2020) already diverges from the established terminology of technostress creators or techno-stressors and "calls for contextualizing general theories in IS research" (Benlian, 2020, p. 1263). He uses the term "technology-driven work stressors" to emphasize "the socio-technical nature of ICT that essentially and distinctly shapes the frequency, valence, and intensity of the stress experienced at work" (Benlian, 2020, p. 1263). However, he uses this term without explicitly defining it. The term is focused on the technology itself, as is the contemporary term technostress creator. Therefore, like Benlian (2020), we borrow from general psychology (Lazarus & Folkman, 1984), work psychology (Bakker and Demerouti 2007), and management literature (Kirmeyer, 1988) and use the word "demand" which also appears in Tarafdar et al. (2007), Ragu-Nathan et al. (2008), Ayyagari et al. (2011), and Bakker and Demerouti (2007). Specifically, we use the term "digital work demands," which we define as job demands caused by working with digital technologies. According to Demerouti et al. (2001, p. 501) "job demands refer to those physical, social, or organizational aspects of the job that require sustained physical or mental effort and are therefore associated with certain physiological and psychological costs."

Combining the results of the literature review, expert interviews, and the focus groups, we define twelve digital work demands. These include *uncertainty, insecurity, complexity,* *invasion*, and *overload* from the technostress concept elucidated by Tarafdar et al. (2007) and Ragu-Nathan et al. (2008), supplemented by the demands of *unreliability* (from Fischer & Riedl, 2015 and Adam et al., 2017), *role ambiguity* and *invasion of privacy* (from Ayyagari et al., 2011), and *interruptions* (from Galluch et al., 2015). These latter demands are already used sporadically and separately in technostress literature but have not yet been included in an overall construct of technostress.

Through our expert interviews and focus groups, we identified three new digital work demands not yet identified by the existing literature on technostress: *performance control*, *nonavailability*, and *lacking a sense of achievement*. Performance control is the perception of being constantly monitored and assessed. This is mainly caused by the increasing ability of modern technology to collect data and compare performance data among individuals. Nonavailability is the perceived conflict between knowing how to fix problems or facilitate work processes by using new technology and not being able to do so because of organizational restrictions. Lacking a sense of achievement is the perception of not having made significant progress during one’s work. This is mainly caused by perceived difficulty in assessing work already completed because of its digital and nonphysical nature. Table 3 summarizes all twelve digital work demands.

Table 3. Definition of the Twelve Digital Work Demands.

Demand	Definition
Invasion	Invasion "describes the invasive effect of [digital technologies] in terms of creating situations where users can potentially be reached anytime, employees feel the need to be constantly 'connected,' and there is a blurring between work-related and personal contexts" (Tarafdar et al., 2007, p. 311).
Overload	Overload "describes situations where [digital technologies] force users to work faster and longer" (Tarafdar et al., 2007, p. 311).
Complexity	Complexity "describes situations where the complexity associated with [digital technologies] makes users feel inadequate as far as their skills are concerned and force them to spend time and effort in learning and understanding various aspects of" digital technologies (Tarafdar et al., 2007, p. 311).
Insecurity	Insecurity "is associated with situations where users feel threatened about losing their jobs as a result of new [digital technologies] replacing them, or to other people who have a better understanding of" digital technologies (Tarafdar et al., 2007, p. 311).
Uncertainty	Uncertainty "refers to contexts where continuing changes and upgrades in an [digital technology] unsettle users and create uncertainty for them, in that they have to constantly learn and educate themselves about the new" digital technologies (Tarafdar et al., 2007, p. 311).
Unreliability	Unreliability describes situations in which individuals "face system malfunctions and other […] hassles" with digital technologies (Fischer & Riedl, 2015, p. 1462).
Role Ambiguity	Role ambiguity is associated with situations where "there is uncertainty as to whether an individual should expend his or her resources to perform the task requirements at work or to acquire new skills" (Ayyagari et al., 2011, p. 842).
Invasion of Privacy	Invasion of privacy refers to situations in which individuals "are becoming increasingly concerned that their privacy could be invaded by" digital technologies (Ayyagari et al., 2011, p. 841, based on Best et al., 2006).
Interruptions	Interruptions describe situations where individuals attention is shifted away from a current task by an external, digital-technology-based source (Galluch et al., 2015).
Performance Control	Performance control describes situations where individuals feel that digital technologies are used to monitor and assess their performance.
Nonavailability	Non-availability refers to situations where individuals are impaired in their activities because digital technologies, which might facilitate or ease work processes, are unavailable due to organizational restrictions, safety, or monetary reasons.
Lacking a Sense of Achievement	Lacking sense of achievement refers to situations where individuals feel that they hardly make work progress as completed tasks with digital technologies can be assessed poorly due to their digital, non-physical nature.

4.5. Quantitative Phase

The quantitative research phase assessed the identified twelve digital work demands from a positivist perspective. Specifically, we used cross-sectional survey data to test convergent, discriminant, and nomological validity. Along the way, we developed and validated a measurement instrument for digital work demands, demonstrated their prevalence, and identified a higher-order structure among these demands. The nomological net is a fundamental tool for understanding constructs and building theory. Cronbach and Meehl (1955, p. 294) state that "scientifically speaking, to make clear what something is means to set forth the laws in which it occurs. We shall refer to the interlocking system of laws that constitute a theory as a nomological network." This is done by embedding the construct of interest—in our case, the identified twelve digital work demands—in a nomological net with theoretically related entities and empirically testing these relationships.

4.5.1. Developing the Measurement Model

The measurement instrument used to assess the latent digital work demands is essential for quantitative investigation. For most of the digital work demands, validated survey scales exist. However, measurement instruments had to be developed from scratch for the newly revealed demands (i.e., nonavailability, performance control, and lacking a sense of achievement). Therefore, we followed the guidelines for developing and evaluating measurement instruments by Hinkin (1998) and MacKenzie et al. (2011). We give an overview of the steps suggested by MacKenzie et al. (2011) here and provide the details including additional numbers for each step in Appendix A.

Step 1: *Develop a conceptual definition of the construct.* This step has been covered in Phase 1c of our mixed-methods study (see Table 3).

Step 2: *Generate items to represent the construct.* We used the validated measurement instruments from Ragu-Nathan et al. (2008) for overload, invasion, complexity, insecurity, and uncertainty, from Ayyagari et al. (2011) for role ambiguity, invasion of privacy, and unreliability, and Galluch et al. (2015) for interruptions. For the newly identified demands, non-availability, performance control, and lacking sense of achievement, we developed six items each based on the definitions of these constructs (Table 3) considering standard guidelines (Hinkin, 1998; MacKenzie et al., 2011; Podsakoff et al., 2003).

Step 3: *Assess the content validity of the items.* We performed a card-sorting exercise with 39 participants and revised the wording of the newly developed items where necessary.

Step 4: *Formally specify the measurement model.* We specified the measurement model as first-order reflective for each of the established scales as suggested by Ragu-Nathan et al. (2008) and likewise for the newly developed scales. Furthermore, we allowed for correlation among the twelve demands. In a later step, we investigated whether there are higher-order structures among the twelve demands.

Steps 5 & 6: *Collect data to conduct pre-test & scale purification and refinement.* We ran a pre-test with n_1 = 445 participants in an online survey (pre-test sample). For this sample and the two following samples (developmental, validation), participants were German workers recruited via an external panel provider. We performed an exploratory factor analysis (EFA) on data from the pre-test sample. For nonavailability and lacking a sense of achievement, the EFA revealed a lack of convergent validity triggering a rewording of some items.

Steps 7 & 8: *Gather data from new sample and reexamine scale properties.* Using the revised scales, we collected a new data set from a large-scale study with 4,560 respondents participating in an online survey. The sample was recruited via the same external research panel as the pre-test. Respondents were paid 3.70 USD/3.10 EUR for their participation. We randomly split our study population into a subset for developmental purposes (developmental sample; n_2 = 1,560) and a subset for validation purposes (validation sample; n_3 = 3,000). Steps 7 and 8 were performed on the developmental sample to reassess scale properties, while all consecutive steps were performed on the validation sample. A confirmatory factor analysis (CFA) showed a good fit. Likewise, standard thresholds for discriminant and convergent validity were met. Further, Cronbach's alpha showed satisfactory values for the twelve demands from digital work. Details on the numbers are presented in Appendix A.

MacKenzie et al. (2011) mention that Step 8 should also examine the extent to which a multidimensional structure is present, as we already pointed out in our fourth step. We thus move discussion of Steps 8 and 9 to the following subsections, where we describe how we used the developmental sample (n_2 = 1,560) to investigate the structure of the twelve demands. Next, we employed the new data from the validation sample (n_3 = 3,000) to reassess scale validity, select among the potential structures of the demands, and embed the final structure in a nomological net. We omitted Step 10 (norm development), as it is not relevant for our research questions.

Overall, these steps suggested by MacKenzie et al. (2011) led us to a validated measurement instrument for all twelve digital work demands. Details on these steps are provided in Appendix A. The final scales are given in Appendix B.

4.5.2. Identification of the Structure

The definitions and the high number of digital work demands suggest that they may not all be completely unrelated. For example, acute demands such as interruptions and unreliability might be grouped, as might more chronic demands such as insecurity and uncertainty. Similarly, invasion of privacy and performance control both involve collecting or accessing personal data by third parties—the first focuses on the private life and the second focuses on the working life. Thus, on theoretical grounds, there is no reason to believe that the demands are unrelated (we therefore used oblique rotation in the EFA for developing the measurement model, Step 6). Furthermore, the above reasoning also suggests that there might be a higher-order structure at play. Understanding the underlying structure is desirable because it leads to stronger theory. Weber (2012) discusses a trade-off between parsimony and a theory's predictive and/or explanatory power and recommends, referring to the work of Miller (1956), , that there should be no more than seven constructs, in order to reduce complexity to a manageable level. Accordingly, we sought to condense our twelve digital work demands into a few higher-order factors in order to highlight their interrelations.

The four different possible models identified by Rindskopf and Rose (1988) for such structures are illustrated in Figure 2 using three factors and five items rather than the twelve factors and three to five items that we have. From prior literature (e.g., Ayyagari et al., 2011; Ragu-Nathan et al., 2008; Tarafdar et al., 2007) and our parallel and MAP analyses in the development of the measurement model (Step 6), we know that the structure of digital work demands does not correspond to the one-factor model. Prior research such as Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) assume a model with one reflective second-order factor while Ayyagari et al. (2011) assume a model of correlated group factors. Given that we are dealing with a rather high number of twelve digital work demands, the question arises whether the model of correlated group factors is most appropriate or whether a second-order model or a bi-factor model might be a better fit. The factor analysis presented so far provides us with an understanding of the structure of the twelve correlated group factors. Thus, we empirically explored the second-order model and bi-factor model on the developmental sample (n_2 = 1,560) and then used the validation sample (n_3 = 3,000) to select the best model for the new data.

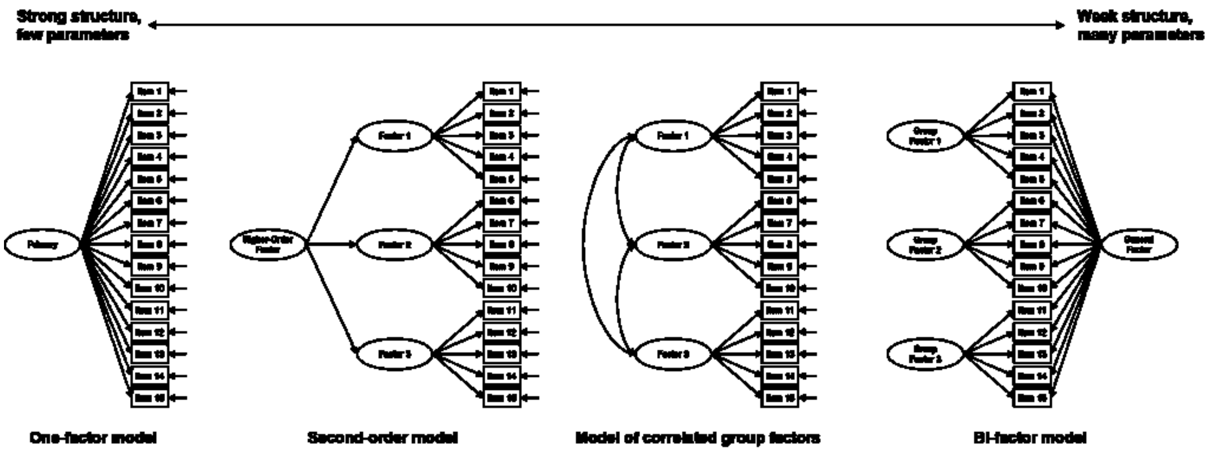

Figure 2. Possible Models Based on Rindskopf and Rose (1988); Note. Circles represent

latent factors, squares represent manifest variables; simplified presentation with few factors and variables.

Extracting the twelve demands in an EFA with oblique rotation on the data from the developmental sample yielded high correlations between 0.27 and 0.75 (see Appendix A), suggesting a potential second-order structure, and a multilevel exploratory factor analysis run on the developmental sample revealed a possible higher-order structure (Naruz et al., 2015). We first applied an EFA with twelve predefined factors. The correlations of the factor score estimates were extracted and used as input to run another EFA (principal axis factoring with oblique rotation).

Table 4. Factor Loadings for 4 Second-Order Factors.

Construct	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
Complexity	0.51			
Invasion	0.41			
Non-Availability	0.51			
Lacking Sense of Achievement	0.79			
Role Ambiguity	0.75			
Interruptions		0.41		
Overload		0.56		
Unreliability		0.46		
Insecurity			0.83	
Uncertainty			0.56	
Invasion of Privacy				0.88
Performance Control				0.69

Note. Loadings < 0.4 are not displayed.

Parallel analysis suggested four or five factors; for the fifth factor, the eigenvalue comparison between actual and simulated data showed only a marginal difference. Thus, we extracted five factors in an EFA similar to that run previously and inspected the loadings. For the fifth factor, the maximum loading of any of the first-order factors was 0.37, below the conventional threshold of 0.4 necessary to consider it a major loading. Hence, we decided to drop the fifth factor and extracted four factors in an EFA with oblique rotation (Table 4).

This resulted in a desirable loading matrix with each first-order factor loading highly on exactly one second-order factor (loadings ranging from 0.413 to 0.884 all exceeding the 0.4 threshold). The matrix revealed no major cross-loading (maximum is 0.36 and no cross-loading greater than half of the loading on the respective other factor). Moreover, each second-order factor was relevant in the sense that at least one first-order factor loaded high on it. Table 5 presents definitions, and explanations for the four higher-order digital work demands we identified: impediment, interference, constant change, and exposure.

Table 5. Explanation, Definition, and Interpretation of Higher-Order Factors.

Higher-Order Digital Work Demand	**Definition**	**Explanation**
Impediment	Impediment describes the digital work demands from complexity, invasion, non-availability, lack of sense of achievement, and role ambiguity.	During a workday, different activities must be carried out to achieve the objectives associated with the work role. However, the (steady) presence or absence of digital technologies may contribute to the perception that making progress in achieving the objectives is more complicated in digital work than non-digital work.
Interference	Interference describes the digital work demands arising from interruptions, overload, and unreliability.	Digital technologies aim to support the handling of tasks in everyday work by facilitating communication and collaboration with others and accomplishing activities. However, digital technologies can also foster the perception that task execution is prolonged due to incidents occurring during the direct interaction with the technologies or interferences caused by third parties using technologies.

Higher-Order Digital Work Demand	**Definition**	**Explanation**
Constant Change	Constant change describes the digital work demands arising from insecurity and uncertainty.	New digital technologies and technology-related work routines lead to higher demands of building up the necessary skills and abilities to carry out work-related tasks or cause job requirements not to be fulfilled due to incorrect or inefficient use of digital technologies.
Exposure	Exposure describes the digital work demands from invasion of privacy and performance control.	The use of digital technologies leaves digital trace data with varying visibility. The increasing use of connected digital technologies enables easier access and simplified processing of these data and may foster the perception that information about persons from different contexts and sources is provided to third parties.

Although the bi-factor model might best describe the interrelation of digital work demands, the bi-factor model has the weakest structure of the models considered here, consisting of one general factor (shown on the far-right side of Figure 2) and multiple group factors. In a bi-factor model, each item loads onto a general factor that represents the individual differences in the target dimension in which the researcher is most interested (in our case technostress). The bi-factor model also specifies two or more group factors that are orthogonal to the general factor (Dunn & McCray, 2020), which are common factors measured by multiple items that explain variance not reflected in the general factor. We ran an EFA using the bi-factor approach suggested by Jennrich and Bentler (2011) to extract a general factor and twelve group factors. All items loaded highly on the general factor. For each of the group factors, at least half of the items related to the respective first-order demand loaded on the group factor.

4.5.3. Selection and Validation

We used the second subsample (validation sample, n_3 = 3,000) and covariance-based structural equation modeling to determine which structure of digital work demands fit best and then embedded it in a nomological net. Table 6 characterizes the sample with respect to demographics and work-related factors. Appendix C lists the psychometric properties of our scales for digital work demands. We added two outcome-related constructs to the survey to assess nomological validity: exhaustion and job satisfaction, defined as the extent to which an employee likes his or her work. Exhaustion was measured with nine items (Maslach & Jackson, 1986), and job satisfaction was measured with six items (Agho et al., 1992).

Table 6. Demographic Properties of the Validation Sample (n_3 = 3,000).

Gender	***N***	**%**		**Employment**	***N***	%
Male	1,623	54		Full-Time (>20 h)	2,886	96
Female	1,377	46		Half-Time (<20 h)	114	4
Age (*M* = 43.19)	***N***	**%**		**Technology Use**	***N***	**%**
<25	108	4		Never	0	0
25-34	704	23		Seldom	0	0
35-44	815	27		Weekly	192	6
45-54	766	26		Daily	330	11
55-64	593	20		Several Times a Day	2478	83
>65	14	<1				

Education	***N***	**%**
Primary/Lower Secondary School Leaving Certificate	49	2
Intermediate School Leaving Certificate	360	12
Higher Education Entrance Qualification	310	10
Apprenticeship	985	33
University Degree (Bachelor)	491	16
University Degree (Master)	694	23
Doctorate	111	4

We conducted Harman's single factor test and applied a correlational marker technique as a post hoc test for common-method bias (CMB) (Richardson et al., 2009). Both analyses suggest that CMB is not a serious threat for our data (details in Appendix C).

We evaluated the model fit according to standard fit measures like RMSEA and SRMR for global measures, CFI, TLI, and NFI for incremental measures, and AGFI to assess model parsimony (Gefen et al., 2000; Lei & Wu, 2007). We do not report χ^2 or χ^2/df, as these are not considered meaningful for samples of our size. The results are displayed in Table 7.

Table 7. Fit Measures for the Different Model from a CFA on the Validation Sample (n_3 = 3,000).

Fit Measures		**Threshold**	**Source of Threshold**	**Second-Order Model**	**Correlated Group Factors**	**Bi-Factor Model**
Global Measures	RMSEA	< 0.06	Lei and Wu (2007)	0.050 ✓	0.048 ✓	0.063 X
	SRMR	< 0.05	Gefen et al. (2000)	0.049 ✓	0.044 ✓	0.126 X
Incremental Measures	NFI	> 0.90	Gefen et al. (2000)	0.926 ✓	0.932 ✓	0.889 X
	TLI	> 0.90	Gefen et al. (2000)	0.930 ✓	0.934 ✓	0.888 X
	CFI	> 0.90	Gefen et al. (2000)	0.934 ✓	0.940 ✓	0.897 X
Parsimony	AGFI	> 0.80	Gefen et al. (2000)	0.866 ✓	0.872 ✓	0.830 X

Note. ✓ indicates that a threshold is met, x indicates that it is not met.

Our results reveal that the data do not adequately fit the bi-factor model but fit both the second-order and the correlated group factors model reasonably well. Despite marginally better fit values for the model of correlated group factors, we adopted the second-order model of digital work demands because it has a stronger structure with fewer parameters and is parsimonious. Parsimony is generally considered to be a beneficial characteristic of theoretical models (Popper, 2005). Further, such second-order conceptualization is in line with the seminal contributions by Tarafdar et al. (2007) and Ragu-Nathan et al. (2008), given our broader set of digital work demands, we identified four rather than one second-order factor: namely, *impediment*, *interference*, *constant change*, and *exposure*.

Next, we embedded the second-order model in a nomological net. Based on prior literature, we decided to investigate job satisfaction and exhaustion as consequences of digital work demands (Gaudioso et al., 2017; Tarafdar et al., 2010). Like Tarafdar et al. (2007) and Ragu-Nathan et al. (2008) we assumed that they are affected not by first-order demands but by second-order demands. We embedded sex, age, and frequency of technology use for the execution of work tasks as relevant control variables in the model.

We hypothesize that the steady presence or absence of digital technologies might lead to less satisfying work results and frustration—for example, when a task could be easily completed with technology not available at work. For this reason, we expect the second-order factor of impediment to have a negative effect on job satisfaction (H1a) and a positive effect on exhaustion (H1b). Feeling hampered in completing one's own tasks by digital technologies is mentally draining and prolongs the completion of tasks. Thus, we hypothesize a negative relationship between the second-order factor of interference and job satisfaction (H2a) and a positive effect between interference and exhaustion (H2b). We also expect that a decreasing reliance on existing skills coupled with the constant need to keep skills up to date may be exhausting. Thus, we hypothesize that the second-order factor of constant change negatively affects job satisfaction (H3a) and positively affects exhaustion (H3b). Finally, we assume that feeling constantly monitored or fearing that information could be provided to third parties makes for an unpleasant work environment. Thus, we hypothesize a negative relationship between the second-order factor of exposure and job satisfaction (H4a) and a positive effect between exposure and exhaustion (H4b).

These hypothesized negative effects of technostress on job satisfaction and exhaustion are in line with prior theorizing and empirical evidence (e.g., Boonjing & Chanvarasuth, 2017; Fieseler et al., 2014; Gaudioso et al., 2016; Tarafdar et al., 2010; Tu et al., 2008). Regarding the three control variables, we assume that age is positively related to job satisfaction and negatively related to exhaustion because of higher coping skills and more accumulated work experience among older workers compared to younger ones (Fritsche & Parrish; Hsu, 2019). While prior research suggests almost no gender difference in job satisfaction (Fritsche & Parrish), women are more likely to experience exhaustion than men (Rubino et al., 2013). Given the highly ambivalent characteristics of technology and its use, ranging from higher levels of flexibility to dilution of the boundaries between work and private life, we assume no effect of technology use on either job satisfaction or exhaustion (Sandoval-Reyes et al., 2019).

We used covariance-based structural equation modeling (CB-SEM) to test the resulting model. The model fit the data from the validation sample well. NFI, TLI, and CFI (NFI = 0.91, TLI = 0.92, CFI = 0.92) showed good values, as did RMSEA and SRMR (RMSEA = 0.05, SRMR = 0.05) for the incremental fit and AGFI for the parsimony of the model (AGFI = 0.88). The analysis showed that all first-order factors loaded on their assumed second-order factor with loadings ranging between 0.65 and 0.94 (Figure 3). Out of the three control variables, we observed a significant effect of age on job satisfaction ($\beta = 0.14$, $z = 7.38$, $p < .001$) and of gender on exhaustion ($\beta = -0.06$, $z = -3.90$, $p < .001$). There were no statistically significant effects (at the 5% level) of technology use on either of the dependent variables.

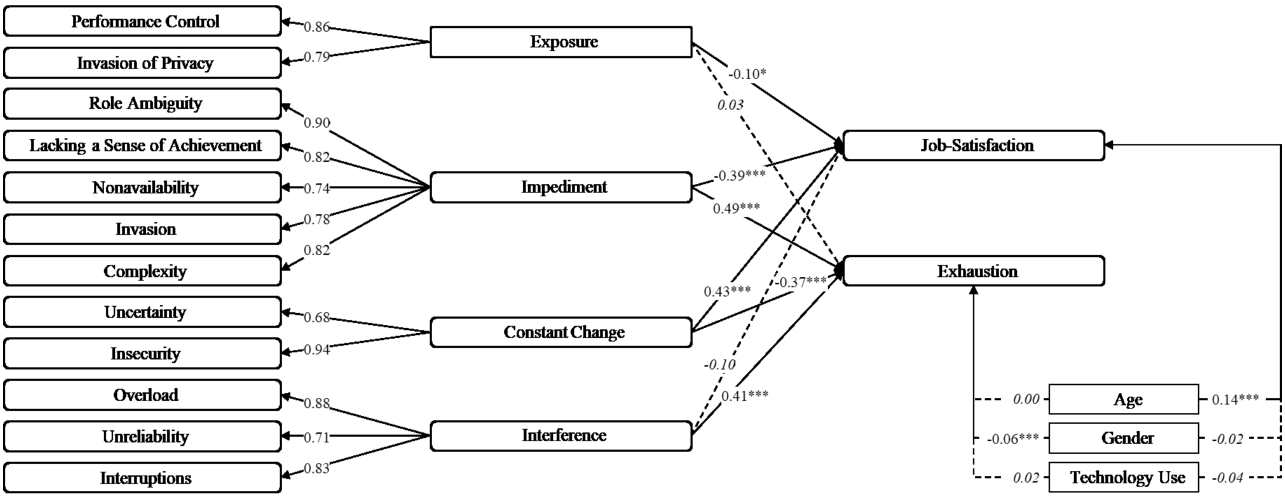

*Figure 3. Nomological Net of Digital Work Demands and their Consequences; hypothesized effects and effects of control variables that are not significant are denoted by dashed lines and italic font; . p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001*

Regarding the hypothesized effects of the second-order demands from digital work, our results show that impediment (β = -0.39, *z* = -4.78, *p* < .001) and exposure (β = -0.10, *z* = -2.29, *p* = .020) negatively relate to job satisfaction whereas constant change is positively associated with job satisfaction (β = 0.43, *z* = 6.90, *p* < .001). The relationship between interference and job satisfaction is not significant. Thus, H1a and H4a are supported by the data, while H2a and H3a are not supported. Impediment is also positively associated with exhaustion (β = 0.49, *z* = -7.06, *p* < .001), as is interference (β = 0.41, *z* = 4.55, *p* < .001). Further, constant change (β = -0.37, *z* = -7.14, *p* < .001) is negatively related to exhaustion, and the relationship between exposure and exhaustion is not significant. Therefore, H1b and H2b are supported by the data, while H3b and H4b are not supported. Overall, this analysis shows that the newly identified digital work demands and their structure of four second-order demands are well-integrated with relevant and well-known consequences of stress at work.

4.6. Discussion

This paper seeks to provide a contemporary perspective to the established research stream of psychological stress caused by working with digital technologies. The context of work has changed substantially under the umbrella term of digital transformation (Vial, 2019). We follow recent calls to update the understanding of digital work demands that cause stress (Fischer et al., 2019; Tarafdar et al., 2019) and address broader calls for contextualizing theories in IS research (Hong et al., 2014). We united nine different digital work demands found in prior research in a single model. Based on qualitative interviews and focus groups, we identified three novel digital work demands and added them to the model: nonavailability, performance control, and lacking a sense of achievement. In a series of quantitative survey-based studies, we discerned four higher-order digital work demands (exposure, impediment, constant change, interference).

Although stress is individual and situational, with demands differing over time and between individuals, the ranking of average digital work demands based on intensity reported by the 3,000 employees from the validation sample is informative (Table 13). In terms of aggregate values, employees perceive the strongest demands from the two first-order constructs related to exposure: performance control and invasion of privacy. This indicates that employees are deeply concerned about how their data are handled within the company. The high intensity of perceived performance control shows the relevance of the addition of this new factor to the repertoire of digital work demands. While the second and third strongest demands, invasion of privacy (Ayyagari et al., 2011) and unreliability (Adam et al., 2017; Fischer & Riedl, 2015), have been previously discussed as technostress creators, they had not yet been integrated in an overarching framework along with the five classical technostress creators identified by Tarafdar et al. (2007) and Ragu-Nathan et al. (2008). The strong perception of these demands highlights the need for an integrated consideration of all the different digital work demands. Overall, our ranking shows that the newly identified and integrated digital work demands do not lag behind the classical ones. Thus, extending the set of demands to a contemporary work context reduces parsimony but adds important facets needed to understand the psychological demands currently caused by digital work.

Considering specifically the nomological validity of the higher-order factors, four of eight hypotheses were in line with our expectations: higher impediment correlates with less job satisfaction and more emotional exhaustion. Thus, the steady presence or absence of digital technologies plays a significant role in assessing important aspects of occupational and health outcomes. Further, interference is positively associated with exhaustion; therefore, being hampered by digital technologies in completing tasks can be assumed to be mentally draining. Finally, exposure is negatively associated with job satisfaction, and the awareness of potentially being monitored during work contributes to an unpleasant work environment.

Beyond these expected findings, some of our results seem counterintuitive. Contrary to our expectations, the second-order factor of constant change correlates with higher job satisfaction and less employee exhaustion. A motivational effect may serve as a possible explanatory mechanism. In the transactional stress model (Lazarus & Folkman, 1984), the third kind of stress appraisal is “challenge.” It has much in common with threat appraisal, as it also activates coping resources, but it also has a motivational aspect. This form of appraisal focuses “on the potential for gain or growth inherent in an encounter and …[is] characterized by pleasurable emotions such as eagerness, excitement, and exhilaration” (Lazarus & Folkman, 1984, p. 33). This aspect of technostress was also acknowledged by Tarafdar et al. (2019), who invoked the question of “how and why individuals appraise IS as challenging or thrilling, experience consequent ‘good’ stress, and are faced with positive outcomes” (Tarafdar et al., 2019, p. 14). Benlian (2020) also found technology-driven challenges along with technology-driven hindrance demands. The factor constant change comprises uncertainty and insecurity. If employees feel that they lack the competence to handle digital technologies, it could motivate them to learn. If one invests time and effort to learn and is successful in that endeavor, it could lead to satisfaction and, consequentially, reduce exhaustion.

Inferences from the qualitative strand of our mixed-methods approach led us to a broad set of digital work demands that could be combined into a unified model. Inferences from the quantitative study show that all twelve digital work demands exist, are distinct, and interpretable. Following the developmental purpose of our mixed-methods approach, the meta-inference is that there are twelve demands from digital work. This answers our first research question. Based on this result, a further inference from the quantitative strand is the second-order structure, which answers our second research question.

4.6.1. Advancing the Concept of Technostress to Digital Stress

Arguably, the last fifteen years brought about a substantive change in the nature, pervasiveness, and use of technologies at work. Contemporary digital work is different from former IT-based work (Colbert et al., 2016). This created a new work context. Given the substantial transformation of work and the novel perspective of digital work demands, one may reconsider the concept of technostress itself. As mentioned above, the term "technostress" was introduced in 1982 when the internet was still in its infancy. Since then, the definition has been revised and expanded over time (see Table 9). All of these definitions focus on the user's inability to deal with technology adequately, and some of them even seem to "throw the burden of technostress onto the users" (Sellberg & Susi, 2014, p. 200). However, some dimensions of technostress do not concern the user's (in)capability to use technology adequately. For example, technology-induced stress can occur because of system malfunctions or a lack of appropriate technologies available to accomplish a task. The latter demand is caused not by using digital technologies but by not using them. Likewise, job insecurity is not linked to technology use by the stressed person but to the concern of losing one's job and not being asked to use technology.

To account for these dimensions of technology-related stress, a broader definition of technostress is needed. Furthermore, even though the definition of technostress has been revised and expanded over time, the terminological and theoretical framework is closely related to its period of origin. Since this period, technology, its use, and perception have changed drastically. While the internet has become a universal source of information, new additional digital technologies like mobile computing, social media (Chiappetta, 2017), cloud computing, advanced analytics, artificial intelligence, and the internet of things have found their way into digital work. Therefore, because of its constricting definition, as well as a changing perceptions about and interactions with technologies, "the term of technostress acquires a new meaning" (Chiappetta, 2017, p. 359). There are good reasons to go beyond Chiappetta's (2017) redefinition of technostress and use the term "digital stress" instead.

Table 8. Exemplary Definitions of Technostress and Digital Stress.

Technostress	
Source	**Definition**
Brod, 1984, p. 16	Technostress is a "modern disease of adaptation caused by an inability to cope with new computer technologies in a healthy manner."
Arnetz & Wiholm, 1997, p. 36	Technostress is a "state of mental and physiological arousal observed in certain employees who are heavily dependent on computers in their work."
Weil & Rosen, 1997, p. 5	Technostress is "any negative impact on attitudes, thoughts, behaviors, or body physiology that is caused either directly or indirectly by technology."
Tarafdar et al., 2007, p. 304	"Technostress, therefore, is one of the fallouts of an individual's attempts and struggles to deal with constantly evolving [digital technologies] and the changing cognitive and social requirements related to their use."
Ragu-Nathan et al., 2008, p. 418	Technostress "is stress experienced by individuals due to the use of ICTs."

Source	Definition
Wang et al., 2008, p. 3004	"In summary, we define technostress as a reflection of one's discomposure, fear, tenseness and anxiety when one is learning and using computer technology directly or indirectly that ultimately ends in psychological and emotional repulsion and prevents one from further learning or using computer technology."
Salanova et al., 2013, p. 423	Technostress is a "negative psychological state associated with the use or threat of digital technology use in the future."
Tarafdar et al., 2019, p. 7	Technostress is "stress that individuals experience due to their use of Information Systems."
Califf et al., 2020, p. 812	"Technostress is conceptually defined as 'a modern disease of adaptation caused by an inability to cope with new computer technologies in a healthy manner' (Brod 1984, p. 16). In IS research, technostress is composed of five dimensions. These dimensions are collectively known as techno-stressors, which are considered harmful stressors that induce deleterious individual and workplace outcomes (Tarafdar et al. 2007; Tarafdar et al. 2017). [...] The five techno-stressors are techno-overload, techno-invasion, techno-complexity, techno- insecurity, and techno-uncertainty (Ragu-Nathan et al. 2008)."
Digital Stress	
Source	**Definition**
Hefner & Vorderer, 2016, p. 237	Digital stress has been defined as the "stress resulting from a strong and perhaps almost permanent use of information and communication technology… that is triggered by permanent access to an inconceivable amount and diversity of (social) content."
Weinstein & Selman, 2016, p. 392	Digital stress is "stress related to [...] digital social lives."
Reinecke et al., 2016, p. 6	Digital stress is defined as "stress reactions elicited by environmental demands originating from digital technology use."
Fischer & Riedl, 2020, p. 219	"Digital stress is a form of stress, which is caused by interaction with information and communication technologies and by their omnipresence in economy and society."

Even though these terms may seem interchangeable, we believe they differ from each other in important ways. As mentioned above, technostress is often defined rather narrowly by focusing on the use of digital technologies, oftentimes in a work context. Instead, digital stress has a broader general meaning. Fischer and Riedl (2020) emphasize the use of digital stress beyond the workplace context by defining digital stress as "a form of stress caused by interaction with information and communication technologies and by their omnipresence in economy and society." The term digital stress is broader because it terminologically includes digitalization at large as a source of stress rather than focusing only on technologies. In this, we consider digitalization to be a sociotechnical phenomenon and view the processes of adopting and using digital technologies in broader individual, organizational, and societal contexts (Legner et al., 2017). Further, by being less technology-centric than the term technostress, digital stress better represents the fact that it is not the technology alone that creates stress but rather our individual and collective use of and perspectives on technology. In addition, several definitions of technostress (e.g., Salanova et al., 2013; Tarafdar et al., 2007) focus on use, yet use is not required for stress to emerge when considering the nonavailability of needed technologies or the threat of losing one's job to new technologies (techno-insecurity, Ragu-Nathan et al., 2008; Tarafdar et al., 2007) or non-availability of technologies.

In summary, digital stress contains all aspects of the technostress concept while also including further aspects of technologically induced stress that have arisen in the course of digitalization. Interactions with information and communication technologies, for example, comprise both the role of the user and the role of (unreliable or nonavailable) technology. In addition, Steele et al. (2020) attribute an essential role to digital stress when trying to understand how digital media, in general, and social media, in particular, affect adolescents and young adults. Against this background, Weinstein and Selman (2016) identify several digital demands, such as the pressure to comply or public shaming and humiliation, by investigating the private use of digital media by adolescents.

Furthermore, by adopting the broader digital stress concept, we see an opportunity to terminologically unite the multidisciplinary research field of technology-induced stress. Currently, “the use of numerous terminologies for similar or identical constructs complicates the literature” (Steele et al., 2020, p. 18). Focusing on a single term that includes the research aspects of both private and work life spanning user ages ranging from the very young to the elderly would prevent obscuring results among studies and therefore make it easier to bring together the results of different disciplines and to understand the phenomenon of digital stress in its entirety (Steele et al., 2020). The nomenclature of digital stress could unify different terminologies used in the literature and integrate new phenomena and contemporary work practices relating to digital technologies that cause stress.

Considering prior definitions of technostress and digital stress along with general definitions of stress (Lazarus & Folkman, 1984; Selye, 1973), we define digital stress as the physiological, emotional, and/or cognitive reaction of an individual to an imbalance between the demands directly or indirectly imposed on the individual through interactions with digital technologies and the available resources and coping measures available to meet these demands. These demands result either directly from the use of digital technologies by the individual, indirectly through the digital technologies themselves, or from the use of digital technologies by third parties. For digital technologies, we adapt the definition from Bharadwaj et al. (2013, p. 471), who define them as “combinations of information, computing, communication, and connectivity technologies.” While the given definition comprises digital stress within both private and work contexts, our empirical analysis focuses solely on digital stress encountered in the work context.

4.6.2. Implications for Theory and Research

Our research evaluates the current concept of technostress and its creating factors in the context of contemporary digital work practices. The capabilities, availability, and use of digital technologies at work have considerably expanded and changed over the last ten to fifteen years. The interdependence of communication and information channels and the availability of new technologies have given rise to novel use cases and interaction forms through and with technologies. Our research aligns with Tarafdar et al. (2019, p. 7) who suggested that stress induced by digital technologies is a continually evolving phenomenon with ongoing digitalization. Further, we answer Fischer et al.'s (2019), question of whether the measurement instrument of technostress is still up to date. Against this background, our research makes the following four contributions.

First, we present a holistic set of the most important digital work demands. Nine of these twelve demands have been previously considered in technostress literature, for example, Tarafdar et al. (2007), Ragu-Nathan et al. (2008), Ayyagari et al. (2011), and Galluch et al. (2015). Further, we added three additional digital work demands that tax or potentially exceed workers' resources, creating stress: nonavailability, performance control, and lacking a sense of achievement. We combined all twelve of these demands in a single unified model. A large body of research in IS and related disciplines is currently focused on stress appraisal (e.g., Benlian, 2020; Califf et al., 2020), stress coping (e.g., Pirkkalainen et al., 2019; Tarafdar et al., 2020), stress outcomes (e.g., Chen et al., 2019; La Torre et al., 2020), and the design of stress-sensitive systems (e.g., Adam et al., 2017; Jimenez & Bregenzer, 2018). When stress from digital work is of concern, such endeavors should consider using our unified and updated conceptualization.

Second, empirical evidence and theoretical reasoning bring to light a higher-order structure with four second-order demands from digital work. Prior research has already considered higher-order models (e.g., Ragu-Nathan et al., 2008; Tarafdar et al., 2007; and research building on these articles), suggesting a single unitary second-order factor. In contrast, given the context of contemporary work practices, our substantially broader conceptualization of digital work demands and our large empirical samples identify the structure as multifaceted. Hence, we introduce the new second-order demands of impediment, interference, constant change, and exposure. By adding much needed further dimensions and expanding the concept of technostress from five to twelve dimensions, this hierarchical structure adds depth to the understanding of the increasing complexity of digital stress and identifies links between its dimensions. We encourage fellow researchers to not only solely investigate the twelve dimensions of technostress, but also consider these higher-order demands to understanding technostress on a larger scale and develop preventive and reactive measures against it.

Third, we suggest evolving the concept of technostress to digital stress. We expect that this suggestion is controversial. One of the manifold potential objections could be that terming anything as “digital” is a fad that will fade. It might be considered meaningless transient wording. Second and more concerning, some might fear a discontinuity in the well-established (IS) research stream on technostress. We partially share these concerns. Yet, because of its broader definition, a theory of digital stress as an extension of technostress can consider more aspects of modern private and professional use of technology by individuals over the complete human lifespan. Thus, this theory of digital stress may contribute to terminologically uniting the multidisciplinary research field of technology-induced stress. Future research should engage with the concept of digital stress, to challenge and evolve the definition provided here and develop the nomological net surrounding it in various contexts.

Fourth, we created and validated survey-based measurement scales for newly identified constructs. Further, we validated the compatibility and delineation of these scales with established digital work demands. These scales could be used in future research to measure digital work demands.

4.6.3. Implications for Practice

Our findings contribute to managerial practice in two ways. First, we raise awareness of the broader categories of stress that arise from the individual and collective use of digital technologies and go beyond the established concept of technostress. Especially given that companies, politics, and the public, are trying to keep up with the increasing digitalization and all its expected benefits, it is important to emphasize potential negative effects associated with digitalization because these effects can only be inhibited or prevented if they are known.

Second, we go beyond raising awareness and offer a psychological risk assessment tool for the workplace context. With the help of our measurement instrument for digital stress exposure, companies can determine which of the twelve digital work demands are most relevant for their employees. Based on company-specific assessment, specific measurements for prevention or counteraction could be developed and implemented either for the entire company or for specific employee groups experiencing high levels of digital stress.

4.6.4. Evaluation and Limitations

According to the classification of Gregor (2006), our conceptualization of demands and digital stress constitutes a type IV theory for explaining and predicting. We propose that digital stress is a physiological, emotional, and/or cognitive reaction of an individual to an imbalance between the demands directly or indirectly imposed on the individual through interaction with digital technologies and the available resources and coping measures. Digital stress in the work domain arises primarily from twelve demands of digital work combined in a hierarchical structure of four second-order demands: impediment, interference, constant change, and exposure. Each of these constructs is associated with job satisfaction and exhaustion. According to Weber (2012), we suggest evaluating our theoretical contribution, as shown in Table 9.

Table 9. Evaluation of our Contribution to Digital Stress Theory according to Weber's (2012) Guidelines.

Criterion	Summary Evaluation
Parts	
Constructs	We deduced the constructs from literature, qualitative interviews, focus groups, and quantitative survey data according to our mixed-methods approach. We provided definitions for all constructs: digital technologies, digital work (section Conceptual Foundations), digital work demands (section Definition of Twelve Digital Work Demands), twelve specific first-order digital work demands (Table 3), four specific second-order digital work demands (Table 5), job satisfaction and exhaustion (section Validating the Concept of Demands from Digital Work), digital stress, and digital work stress (section Advancing the Concept of Technostress to Digital Stress). The boundary condition for the demands and their consequences is digital work. The demands and their consequences apply to the individual worker level.
Associations	We show and empirically tested the associations of all constructs. The demands originate from digital work and affect job satisfaction and exhaustion. The first-order demands are consolidated to second-order demands as shown in Figure 3.
States	Digital work demands, job satisfaction, and exhaustion each have a continuous state space. While typically there will be correlations (or non-linear associations) of the state, theoretically, any combination of individual states is possible.
Whole	
Importance	Excessive digital stress leads to negative humanistic (e.g., reduced satisfaction, well-being, health) and instrumental outcomes (e.g., increased exhaustion, increased job turnover). Since not only the sheer number and functionalities of digital technologies have enormously increased in the last ten to fifteen years but also the interaction with these technologies has considerably changed due to availability, a changed individual and social view of technologies, and expectations regarding digitalization, the concept of technostress needed a review.
Novelty	While technostress is already an extensively researched concept, we unite disparate perspectives on demands, add three new digital work demands, and reveal their higher-order structure. Further, we suggest adopting the concept digital stress.
Parsimony	The empirical studies show that the reduction of parsimony compared to prior conceptualizations of technostress brings the benefit of capturing the important demands from contemporary work practices. The second-order structure provides parsimony.
Level	Our contribution resides on the meso level.
Falsifiability	As we clearly defined the constructs and associations and provide measurement instruments for all constructs, our model can be subjected to further empirical tests. Thus, it can be falsified.

Our research has a few limitations. First, our sample in the qualitative study is not representative of all employees. We collected qualitative data from 61 individuals in expert interviews and focus groups but did not select the individuals based on representativeness. Second, in our conclusions drawn from the qualitative data, we did not consider whether participants represented a larger industry or employee group in the working world but took all of their statements equally into account. However, following a mixed-methods approach and combining qualitative and quantitative research strands likely mitigated any potential problems related to these issues because our qualitative results were tested in a large-scale quantitative analysis. Third, we collected the quantitative data with the help of online surveys providing financial incentives. Typical weaknesses of this method, such as self-selection of the population, nonresponse, and questionable reliability of expressed opinions (Nayak & Narayan, 2019), should be considered when interpreting our results. Fourth, our three newly identified digital work demands—nonavailability, lacking a sense of achievement, and performance control—were tested using multiple large data sets based on employees in Germany. Future work should seek to validate our results in other economic and cultural backgrounds. Finally, we embedded the digital work demands in a nomological net with job satisfaction and exhaustion. Some hypotheses were not supported and, in two cases, a significant effect of demands on outcomes was observed in the direction opposite from that hypothesized. Future research should delve deeper into these surprising relationships and consider the second-order demands with regard to further consequences (e.g., appraisal, coping behavior) and moderators of the demand-outcome relationship (e.g., resources such as individual characteristics).

4.7. Conclusion

Digitalization is one of the most significant sociotechnical challenges of modern humankind; it has tremendously transformed work practices and altered the demands placed on employees. Our research contributes to understanding these new demands in the age of digital work and thus lays the foundation for further research regarding antecedents, appraisal, coping, outcomes of digital stress, and the design of social, technical, and sociotechnical systems seeking to limit excessive stress and its negative consequences.

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4.9. Appendix A: Development and Validation of Measures

For the development and validation of measures, we followed two different processes depending on the prerequisites. If possible, the use of existing measures is recommended (Urbach & Ahlemann, 2010). In the case of new constructs without existing measures, we followed the guidelines formulated by Hinkin (1998) and MacKenzie et al. (2011). Therefore, the following passages are structured according to the steps recommended by MacKenzie et al. (2011).

Step 1: *Develop a conceptual definition of the construct*

The first step is to define the constructs conceptually and to discuss “how the construct differs from other related constructs” MacKenzie et al. (2011, p. 298). This step has been covered in Phase 1 of our mixed-methods study. The qualitative investigations concluded with a definition of twelve digital work demands, as presented in Table 3 within the research article.

Step 2: *Generate items to represent the construct*

For existing scales, we collected the items from Ragu-Nathan et al. (2008) (i.e., invasion, overload, complexity, insecurity, and uncertainty), Ayyagari et al. (2011) (i.e., unreliability, role ambiguity, and invasion of privacy), and Galluch et al. (2015) (i.e., interruptions). The items were slightly adapted. For example, instead of the wording “technology” or “ICT”, we consistently used the term “digital technology and media”. The items were collected in English and then translated in a four-step approach based on (Beaton et al., 1998) into German since the survey’s final sample consisted of German employees. Therefore, two bilingual speakers translated the questions in parallel. They met afterward to discuss discrepancies with a third bilingual speaker and agree on the most suitable translation. A fourth bilingual speaker back-translated the items into English again and checked the semantic equivalence.

For the newly identified demands, non-availability, performance control, and lacking sense of achievement, we developed items based on the definitions of these constructs (cf. Table 3) considering standard guidelines (Hinkin, 1998; MacKenzie et al., 2011; Podsakoff et al., 2003). We created the items to be short, simple, and precise and used appropriate language for employees (Hinkin, 1998; MacKenzie et al., 2011). During the development, we carefully made sure that the items only address a single aspect (i.e., no connection of different statements in one item) to prevent the respondent's confusion (Hinkin, 1998). High quality of items and careful construction of the statements used are necessary procedural remedies to avoid common method bias (CMB) (Podsakoff et al., 2003). Since it is likely in a scale development process that approximately half of the items may be dropped due to reliability and validity issues (Hinkin, 1998), we generated six items for each creator of digital stress so that at least three items would remain after the validation process. Because the questionnaire was rather long, reverse coded items were included to reduce response patterns in the first draft of the survey. The items of the three new scales were generated in German. We translated the final versions of the items into English for further reusability according to the same procedure as we translated the existing English item scales into German.

We used a five-point Likert-type rating scale from 0 = “I do not agree at all” to 4 = “I totally agree” to measure all twelve demands.

Step 3: *Assess the content validity of the items*

To evaluate the newly developed item scales' content and face validity, we conducted a card-sorting experiment via an online matching task with fellow researchers (Moore & Benbasat, 1991; Thatcher et al., 2018). Thirty-nine participants completed the task. Items that were correctly matched by less than 85 % of participants were subject to refinement. Thus, we changed the wording of these items to fit the corresponding digital work demands better and finished this step of item generation with the revised scales.

Step 4: *Formally specify the measurement model*

We specified the measurement model as first-order reflective for each of the established scales as suggested by Ragu-Nathan et al. (2008, p. 428), who "[…] have conceptualized technostress creators […] as reflective or superordinate (Edwards, 2001; Law & Wong, 1999) constructs. This implies that (1) each of the first order constructs represents a facet or manifestation and can be viewed as one of its dimensions and the direction of causality is from the second order construct to its facets, the first order constructs, (2) the first order constructs are interchangeable, (3) covariation among the first order constructs is not unexpected, and (4) the nomological networks associated with them are expected to be similar (Jarvis et al., 2003)". For the newly developed scales, we followed the suggestion from Ragu-Nathan et al. (2008, p. 428) and are "consistent with previous literature on stress that models stress as a reflective construct (Law et al., 1998)". Furthermore, we allowed for correlation among the twelve demands. In a later step, we investigated whether there are higher-order structures among the twelve demands.

Step 5: *Collect data to conduct pre-test*

Next, we collected data for evaluating our measures' factor structure and validity (Hinkin, 1998; MacKenzie et al., 2011). First, we acquired respondents for a pre-test via an external research panel focusing on the German workforce. Respondents were paid 3.70 USD/3.10 EUR for participation in the study. Four hundred forty-five respondents took part in the study providing data (pre-test sample; $n_1 = 445$) in sufficiently good quality (e.g., consistency checks between individual items, meaningful answers to free-text questions).

Step 6: *Scale purification and refinement*

On the pre-test dataset, we performed an exploratory factor analysis (EFA) to assess the quality of our questionnaire carefully and did a preliminary analysis of all scales (Hinkin, 1998). Parallel analysis (Horn, 1965) suggested to extract nine factors but also showed a strong first factor, which suggests that a minimum average partial (MAP) test (Beauducel, 2001) is more adequate to determine the number of factors to extract (Velicer, 1976). The MAP test suggested 13 factors.

We used principal axis factoring and oblique rotation to identify the factors. As can be seen in Table 14, the items for overload as well as for interruptions loaded on one joint factor. Further, the items for non-availability and for lacking sense of achievement loaded on two separate factors each. These "sub-factors" were compounded of items that were formulated in the same direction. Thus, we decided to reformulate all reversely coded items. Furthermore, we removed the first item of invasion of privacy due to its cross-loading on performance control. As both, the overload and interruptions scales were validated in prior research (even if not used jointly), we for now refrained from adaptations.

Step 7: *Gather data from new sample and reexamine scale properties*

Using the revised scales, we collect a new data set from a large scale-study with 4,560 respondents participating in an online survey through the same external research panel as in the pre-test. We randomly split our study population into a subset for developmental purposes (developmental sample; n_2 = 1,560) and a subset for validation purposes (validation sample; n_3 = 3,000). Step seven and eight is performed on the developmental sample to re-assess scale properties, while all consecutive steps are performed on the validation sample. Table 11 presents the demographic properties of the participants in the developmental sample.

Table 10. Demographic Properties of the Developmental Sample (n_2 = 1,560).

Gender	***N***	**%**	**Employment**	***N***	**%**
Male	834	53	Full-Time (>20 h)	1488	95
Female	726	47	Half-Time (<20 h)	72	5
Age (*M* = 43.19)	***N***	**%**	**Technology Use**	***N***	**%**
<25	53	3	Never	0	0
25-34	341	22	Seldom	0	0
35-44	427	27	Weekly	80	5
45-54	406	26	Daily	203	13
55-64	328	21	Several Times	1277	82
>65	5	<1			
Education				***N***	**%**
Primary/Lower Secondary School Leaving Certificate				23	1
Intermediate School Leaving Certificate				205	13
Higher Education Entrance Qualification				170	11
Apprenticeship				485	31
University Degree (Bachelor)				286	18
University Degree (Master)				346	22
Doctorate				45	3

Table 11. Item loadings from EFA on Data from the Pre-Test Sample (n1 = 445).

Item	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13
INV01	0.753												
INV02	0.667												
INV03	0.483												
OVE01		0.367											
OVE02		0.529											
OVE03		0.526											
OVE04		0.565											
COM01			0.582										
COM02			0.817										
COM03			0.627										
COM04			0.688										
COM05			0.805										
INS01				0.309									
INS02				0.419									
INS03				0.420									
INS04				0.387									
UNC01					0.650								
UNC02					0.719								
UNC03					0.860								
UNC04					0.917								
UNR01						0.886							
UNR02						0.943							
UNR03						0.764							
ROL01							0.564						
ROL02							0.675						
ROL03							0.781						
ROL04							0.525						

Item	F01	F02	F03	F04	F05	F06	F07	F08	F09	F10	F11	F12	F13
IOP01								0.416	0.439				
IOP02								0.877					
IOP03								0.892					
IOP04								0.834					
INT01		0.318											
INT02		0.330											
INT03		0.328											
PER01									0.571				
PER02									0.668				
PER03									0.798				
PER04									0.702				
PER05									0.758				
PER06									0.675				
NON01										0.901			
NON02										0.909			
NON03											0.676		
NON04											0.778		
NON05											0.766		
NON06										0.476			
LSA01												0.761	
LSA02												0.852	
LSA03												0.850	
LSA04													0.832
LSA05												0.782	
LSA06													0.866

Note. Loadings < 0.4 are not displayed; INV = Invasion, OVE = Overload, COM = Complexity, INS = Insecurity, UNC = Uncertainty, UNR = Unreliability, ROL = Role Ambiguity, IOP = Invasion of Privacy, INT = Interruptions, PER = Performance Control, NON = Non-Availability, LSA = Lacking Sense of Achievement.

Using the revised scales, we conducted a confirmatory factor analysis (CFA) to measure the models' fit according to standard fit measures likes the root mean square error of approximation (RMSEA) and the square root mean residual (SRMR) for global measures, the comparative fit index (CFI), Tucker-Lewis index (TLI), and the Normed Fit Index (NFI) for incremental measures, and the Adjusted Goodness of Fit Index (AGFI) for the assessment of the parsimony. We applied the thresholds suggested by Lei and Wu (2007) and Gefen et al. (2000). We do not report χ^2 or χ^2/df as these are not considered meaningful for samples of our size. Results are displayed in 0.

Table 12. Fit Measures from a CFA Using the Developmental Sample (n_2 = 1,560).

Fit Measures		**Threshold**	**Source of Threshold**	**Twelve Digital Work Demands**
Global Measures	RMSEA	< 0.06	Lei and Wu (2007)	0.050
	SRMR	< 0.05	Gefen et al. (2000)	0.049
Incremental Measures	NFI	> 0.90	Gefen et al. (2000)	0.920
	TLI	> 0.90	Gefen et al. (2000)	0.929
	CFI	> 0.90	Gefen et al. (2000)	0.935
Parsimony	AGFI	> 0.80	Gefen et al. (2000)	0.826

The data from the developmental sample showed a good fit. Furthermore, we evaluated reliability using Cronbach's Alpha and convergent validity using the item loadings and average variance extracted (AVE) from the confirmatory factor analysis. The descriptive statistics, loadings, Cronbach's Alpha values, and AVE are presented in Table 16. Cronbach's Alpha showed values of at least 0.82 for all scales indicating internal consistency. Almost all loadings of the items on their respective latent factors in the CFA were above the value of 0.70, which indicates that the underlying construct explains more than 50 % of the variance of this item. Also, the AVE (i.e., assessing whether, on average, over all items, the underlying latent construct explains more than 50 % of the variation in its indicators in sum) of all constructs was above 0.50. Thus, convergent validity was satisfactory.

Table 13. Descriptive Statistics, Internal Consistency, AVE, and Factor Loadings from the Developmental Sample (n_2 = 1,560).

Construct	**Items**	***M***	***SD***	**Loadings**	**Cronbach's α**	**AVE**
Invasion	3	1.14	1.33	0.64-0.89	0.82	0.60
Overload	4	1.52	1.31	0.71-0.85	0.88	0.66
Complexity	5	1.21	1.21	0.76-0.87	0.91	0.67
Insecurity	4	1.18	1.26	0.69-0.84	0.83	0.57
Uncertainty	4	1.69	1.24	0.76-0.86	0.88	0.65
Unreliability	3	1.75	1.22	0.85-0.94	0.92	0.79
Role Ambiguity	4	1.22	1.23	0.79-0.89	0.91	0.72
Invasion of Privacy	3	1.95	1.38	0.90-0.94	0.93	0.85
Interruptions	3	1.49	1.26	0.85-0.90	0.91	0.76
Performance Control	6	1.95	1.36	0.77-0.88	0.92	0.67
Non-Availability	6	1.19	1.27	0.79-0.88	0.93	0.68
Lacking Sense of Achievement	6	1.04	1.22	0.79-0.94	0.96	0.81

Step 8: *Assess Scale Validity*

Additionally, we assessed the discriminant validity of our twelve constructs amongst themselves based on the Fornell-Larcker criterion (Fornell & Larcker, 1981) as Cronbach's Alpha does not account for the dimensionality of constructs. The Fornell-Larcker criterion compares the size of the intercorrelations of the latent constructs to the AVE. The square root of the AVE printed in the diagonal of Table 17 was higher than the intercorrelations of each construct with the other latent factors. Therefore, we considered construct validity as given.

Table 14. Discriminant Validity According to Fornell-Larcker for the Developmental Sample (n_2 = 1,560).

Construct	INV	OVE	COM	INS	UNC	UNR	ROL	IOP	INT	PER	NON	LSA
INV	**0.78**											
OVE	0.65	**0.82**										
CO	0.63	0.66	**0.82**									
INS	0.73	0.72	0.66	**0.76**								
UNC	0.48	0.56	0.43	0.64	**0.81**							
UNR	0.48	0.62	0.51	0.51	0.43	**0.89**						
ROL	0.65	0.69	0.75	0.68	0.44	0.58	**0.85**					
IOP	0.42	0.49	0.43	0.41	0.27	0.44	0.54	**0.92**				
INT	0.57	0.71	0.61	0.57	0.42	0.62	0.70	0.54	**0.87**			
PER	0.40	0.59	0.45	0.50	0.38	0.45	0.55	0.67	0.55	**0.82**		
NON	0.59	0.54	0.59	0.55	0.34	0.52	0.66	0.44	0.58	0.42	**0.82**	
LSA	0.64	0.62	0.67	0.64	0.41	0.48	0.75	0.47	0.65	0.43	0.64	**0.90**

Note. Diagonal elements are square root AVE; off-diagonal elements are correlations; INV = Invasion, OVE = Overload, COM = Complexity, INS = Insecurity, UNR = Unreliability, ROL = Role Ambiguity, IOP = Invasion of Privacy, INT = Interruptions, PER = Performance Control, NON = Non-Availability, LSA = Lacking Sense of Achievement

The accomplished analyses show that the scales to assess the digital work demands perform well, and there is evidence for twelve underlying factors in the data. The translated scales worked well, just as did the three scales for the newly developed constructs from scratch. Especially as we initially intended to potentially reduce the number of items for non-availability, performance control, and lacking sense of achievement. However, all newly generated items' psychometric properties were good enough for retaining them in the final scales. The final scales from this process are presented in Appendix B.

4.10. Appendix B: Final Scale

Table 15. Items of the Final Scale to Assess Digital Work Demands.

Construct	Item	Loadings
Invasion (Adapted from Tarafdar et al., 2007)	INV01: I have to sacrifice my vacation and weekend time to keep current on digital technologies.	0.817
	INV02: I have to be in touch with my work even during my vacation due to digital technologies.	0.876
	INV03: I feel my personal life is being invaded by digital technologies.	0.650
Overload (Adapted from Tarafdar et al., 2007)	OVE01: I am forced by digital technologies to do more work than I can handle.	0.848
	OVE02: I am forced to work with very tight time schedules by digital technologies.	0.850
	OVE03: I am forced to change my work habits to adapt to new technologies.	0.721
	OVE04: I have a higher workload because of increased technology complexity.	0.864
Complexity (Adapted from Tarafdar et al., 2007)	COM01: I do not know enough about digital technologies to handle my job satisfactorily.	0.772
	COM02: I need a long time to understand and use new technologies.	0.867
	COM03: I do not find enough time to study and upgrade my technology skills.	0.803
	COM04: I find new recruits to this organization know more about computer technologies than I do.	0.769
	COM05: I often find it too complex for me to understand and use new technologies.	0.861
Insecurity (Adapted from Tarafdar et al., 2007)	INS01: I feel constant threat to my job security due to new digital technologies.	0.708
	INS02: I have to constantly update my skills with regard to digital technologies to avoid being replaced.	0.779
	INS03: I am threatened by coworkers with newer technology skills.	0.833
	INS04: I feel there is less sharing of knowledge about digital technologies among coworkers.	0.695

Construct	Item	Loadings
Uncertainty (Adapted from Tarafdar et al., 2007)	UNC01: There are constant changes in computer software in our organization.	0.755
	UNC02: There are constant changes in computer hardware in our organization.	0.791
	UNC03: There are frequent upgrades in computer networks in our organization.	0.806
	UNC04: There are always new developments in the technologies we use in our organization.	0.853
Unreliability (Adapted from Ayyagari et al., 2011)	UNR01: I often experience that features provided by digital technologies are not dependable.	0.863
	UNR02: I often experience that the capabilities provided by digital technologies are not reliable.	0.924
	UNR03: I often experience that digital technologies do not behave in a highly consistent way.	0.870
Role Ambiguity (Adapted from Ayyagari et al., 2011)	ROL01: I am not sure whether I have to deal with problems with digital technologies or with my work activities.	0.869
	ROL02: I am not sure what to prioritize: problems with digital technologies or my work activities.	0.878
	ROL03: I cannot allocate time properly for my work activities because the time spent on solving problems with digital technologies varies.	0.869
	ROL04: Time spent resolving digital technology problems takes time away from fulfilling my work responsibilities.	0.753
Invasion of Privacy (Adapted from Ayyagari et al., 2011)	IOP02: I feel my privacy can be compromised because my activities using digital technologies can be traced.	0.917
	IOP03: I feel my employer could violate my privacy by tracking my activities using digital technologies.	0.945
	IOP04: I feel that my use of digital technologies makes it easier to invade my privacy.	0.895
Interruptions (Adapted from Galluch et al., 2015)	INT01: I received too many interruptions during the task through digital technologies.	0.869
	INT02: I experienced many distractions during the task due to digital technologies.	0.843
	INT03: The interruptions caused by digital technologies are frequent.	0.903

Construct	Item	Loadings
Performance Control (Self-Developed)	PER01: I feel that my professional performance is monitored using digital technologies.	0.788
	PER02: I feel that professional achievements can be better monitored because of digital technologies.	0.818
	PER03: Due to digital technologies other people can easily monitor my performance.	0.878
	PER04: I feel that my professional achievements can be compared with the achievements of my <colleagues/competitors> due to digital technologies.	0.845
	PER05: My performance can be continually assessed through digital technologies.	0.880
	PER06: I have the feeling that more of the mistakes I make during work can be discovered through digital technologies.	0.782
Non-Availability (Self-Developed)	NON01: I do not have the necessary digital technologies at hand that I need to carry out my activities.	0.834
	NON02: The digital technologies available to me are not sufficient to execute my work tasks.	0.846
	NON03: I could do better work if I had more digital technologies available.	0.816
	NON04: I am restricted in the execution of my work tasks because I am lacking essential technologies.	0.896
	NON05: I could handle my work tasks better if I had more rights to the relevant digital technologies.	0.822
	NON06: I do not have the right to use the digital technologies which I need to do my job.	0.801
Lacking Sense of Achievement (Self-Developed)	LSA01: I feel that I do not know what I have accomplished at the end of a working day when using digital technologies.	0.882
	LSA02: When working with digital technologies, I lack the feeling of knowing what I have personally achieved.	0.915
	LSA03: It is hard for me to recognize the results of my work while using digital technologies.	0.928
	LSA04: I can't tell what progress I've made at the end of the day when working with digital technologies.	0.926
	LSA05: It is very difficult for me to recognize my work success and I have to think carefully about what I have actually achieved when using digital technologies.	0.922
	LSA06: Digital technologies do not help me to assess the progress I made at work.	0.810

Table 16. Scales and Items Used to Measure the Outcomes in the Nomological Net.

Construct	**Item**
Job Satisfaction (Adapted from Agho et al., 1992)	SAT01: I find real enjoyment in my job.
	SAT02: I like my job better than the average person.
	SAT03: I am seldom bored with my job.
	SAT04: I would not consider taking another kind of job.
	SAT05: Most days I am enthusiastic about my job.
	SAT06: I feel fairly well satisfied with my job.
Exhaustion (Adapted from Maslach & Jackson, 1986)	EMO01: I feel emotionally drained by my work.
	EMO02: Working at my job all day long requires a great deal of effort.
	EMO03: I feel like my work is breaking me down.
	EMO04: I feel frustrated with my work.
	EMO05: I feel I work too hard on my job.
	EMO06: It stresses me too much to work on my job.
	EMO07: I feel like I am at the end of my rope.
	EMO08: I feel burned out from my work.
	EMO09: I feel used up at the end of the workday.

We conducted Harman’s single factor test to derive whether CMB seems a problem in our data. All items were subject to principal components analysis (Podsakoff et al., 2003). More than one factor was extracted, the largest one accounting for about 13% of the variance, so CMB is considered as uncritical. Second, we employed the correlational marker technique (Richardson et al., 2009). Therefore, we partialled out the smallest and the second-smallest shared variance in bivariate correlations among substantive exogenous latent variables (i.e., digital work demands). Since we found only minor changes in significance of the bivariate correlation among these variables, we assume that CMB is not a concern in this study.

4.11. Appendix C: Psychometric Properties of the Final Scale on the Validation Sample

Table 17. Descriptive Statistics, Internal Consistency, AVE, and Factor Loadings for the Validation Sample (n_3 = 3,000).

Construct	**Items**	***M***	***SD***	**Loadings**	**Cronbach's α**	**AVE**
Invasion	3	1.15	1.32	0.40-0.86	0.82	0.60
Overload	4	1.54	1.31	0.55-0.71	0.89	0.67
Complexity	5	1.16	1.22	0.55-0.87	0.91	0.66
Insecurity	4	1.16	1.27	0.45-0.79	0.83	0.57
Uncertainty	4	1.70	1.25	0.72-0.83	0.88	0.64
Unreliability	3	1.75	1.21	0.78-0.94	0.92	0.78
Role Ambiguity	4	1.20	1.24	0.40-0.61	0.91	0.70
Invasion of Privacy	3	1.81	1.39	0.85-0.98	0.94	0.84
Interruptions	3	1.48	1.27	0.74-0.83	0.90	0.76
Performance Control	6	1.90	1.38	0.65-0.89	0.93	0.69
Non-Availability	6	1.18	1.27	0.66-0.91	0.93	0.70
Lacking Sense of Achievement	6	1.02	1.27	0.70-0.94	0.96	0.80

Table 18. Discriminant Validity According to Fornell-Larcker for the Validation Sample (n_3 = 3,0000).

Construct	INV	OVE	COM	INS	UNC	UNR	ROL	IOP	INT	PER	NON	LSA
INV	**0.78**											
OVE	0.65	**0.82**										
COM	0.63	0.66	**0.81**									
INS	0.73	0.72	0.66	**0.76**								
UNC	0.48	0.56	0.43	0.64	**0.80**							
UNR	0.48	0.62	0.51	0.51	0.43	**0.89**						
ROL	0.65	0.72	0.76	0.68	0.45	0.58	**0.84**					
IOP	0.42	0.49	0.43	0.41	0.27	0.44	0.51	**0.92**				
INT	0.57	0.71	0.61	0.57	0.42	0.62	0.74	0.54	**0.87**			
PER	0.40	0.59	0.45	0.50	0.38	0.45	0.57	0.67	0.55	**0.83**		
NON	0.59	0.54	0.59	0.55	0.34	0.52	0.67	0.44	0.58	0.42	**0.84**	
LSA	0.64	0.62	0.67	0.64	0.41	0.48	0.75	0.47	0.65	0.43	0.64	**0.90**

Note. Diagonal elements are square root AVE; off-diagonal elements are correlations; INV = Invasion, OVE = Overload, COM = Complexity, INS = Insecurity, UNR = Unreliability, ROL = Role Ambiguity, IOP = Invasion of Privacy, INT = Interruptions, PER = Performance Control, NON = Non-Availability, LSA = Lacking Sense of Achievement

4.12. Supplemental Material A: Elaboration of Decision Choice of Mixed-Methods Study Adapted from Venkatesh et al. (2016)

	Property	Decision Consideration	Other design decision(s) likely to affect current decision	Design decision and reference to the decision tree
Step1: decide on the appropriateness of mixed-methods research	Research Questions	Qualitative or quantitative method alone was not adequate for addressing the research question. Thus, we used a mixed-methods research approach	None	Identify the research questions • We wrote the qualitative and quantitative research questions separately first and refrain from asking a mixed-methods research question. • The qualitative research questions were: "Which demands from contemporary work practices relating to digital technologies cause stress for employees?" • The quantitative research question was: "How do the different demands relate to each other?"
	Purpose of mixed-methods research	The purpose of our mixed-methods design was to help develop a research model for empirical testing using the results of the qualitative study given the lack of current research on new technostress creators.	Research questions	Developmental purpose and the results from the qualitative strand were used to develop the research model in the quantitative strand.
	Epistemological perspective	The qualitative and quantitative components of the study used different paradigmatic assumptions.	Research questions, purpose of mixed methods	Multiple paradigm stance.

	Property	Decision Consideration	Other design decision(s) likely to affect current decision	Design decision and reference to the decision tree
	Paradigmatic assumptions	The researchers believed in the importance of research questions and embraced various methodological approaches from different worldviews.	Research questions, purpose of mixed methods	We used the interpretive and grounded-theory perspective in the qualitative study, then applied a positivist perspective, and deductively tested the developed model in the quantitative study.
Step 2: develop strategies for mixed-methods research designs	Design investigation strategy	The mixed-methods study was aimed to develop and test a theory.	Research questions, paradigmatic assumptions	Phase 1: exploratory investigation. Phase 2: confirmatory investigation.
	Strands/phases of research	The study involved multiple phases.	Purpose of mixed methods research	Multistrand design.
	Mixing strategy	The qualitative and quantitative components of the study were mixed at the data-analysis and inferential stages.	Purposes of mixed-methods research, strands/phases of research	Partially mixed methods.
	Time orientation	We started with the qualitative phase, followed by the quantitative phase.	Research questions, strands/phases of research	Sequential (exploratory) design.
	Priority of methodological approach	The qualitative and quantitative components were equally important.	Research questions, strands/phases of research	Equally dominant design with the qualitative and quantitative study being equally important.

	Property	Decision Consideration	Other design decision(s) likely to affect current decision	Design decision and reference to the decision tree
Step 3: develop strategies for collecting and analyzing mixed-methods data	Sampling design strategies	The samples for the quantitative and qualitative components of the study differed, but they came from the same underlying population (parallel samples).	Design investigation strategy, time orientation	Purposive sampling for the qualitative study given interdisciplinary nature of technostress in the working context, probability sampling for the quantitative study.
	Data collection strategies	Qualitative data collection in phase 1. Quantitative data collection in phase 2.	Sampling design strategies, time orientation, strands/phases of research	Qualitative study: open-ended questioning using a pre-designed interview guideline. Quantitative study: closed-ended questioning (i.e., traditional survey design).
	Data analysis strategy		Time orientation, data collection strategy, strands/phases of research	Sequential qualitative-quantitative analysis.

4.13. Supplemental Material B: Mixed-Method Approach and Criteria adapted from Venkatesh et al. (2013)

Quality Aspects	Quality Criteria	Authors' response to Venkatesh et al. 's (2013) guideline
Purpose of mixed method approach	"Development"	This study is divided into two phases: (1) after an extensive literature search, a qualitative study involves 15 interviews with experts on different fields including employee and employer representatives, experts from occupational health management, ethics, ergonomics, informatics, and human resource management followed by seven focus group interviews with employees to understand current factors that could result in technostress (2) multiple large quantitative surveys ($n_{\text{pre-test}}$ = 455, n_1 = 1,560, n_2 = 3,000) to test for the identified factors and their underlying structure. The qualitative study was used to identify the factors for theory building and survey development, which was subsequently tested in the quantitative study.
	Sequential qualitative followed by a quantitative investigation	The scope and objectives of the quantitative investigation using statistical techniques are to support the qualitative investigation and to inspect a potential hierarchical structure.
Design quality	Design adequacy	The study used 15 qualitative interviews with experts from different fields along with an in-depth-analysis of the transcribed data followed by a seven qualitative focus group discussion. After this qualitative phase, a quantitative survey was designed und distributed. This strategy of examining "raw" data from the phenomenon as a "prelude" to the larger quantitative study ensured that the research model tested using the quantitative study was relevant to the phenomenon of interest. In doing so, it sought to combine the advantages of the two approaches, achieving depth and insight into the phenomenon as well as the breadth of coverage.
		Qualitative – Expert Interviews • Selecting suitable interviewees: The interviewees were experts on fields that related to technostress and address this topic from a variety of different perspectives and were thus in sum seen as suitable. • Entering the field with credibility: The interviews were primarily conducted by authors of the manuscript, who were (at the time of the study) working on his/her Ph.D. thesis (thus seen in high respect in society). • Conduct of interviews: All interviews were conducted using a pre-designed interview guideline. *Qualitative – Focus Group Discussion* • Selecting suitable interviewees: The interviewees were groups of white-collar-workers of different companies using digital technologies to perform their work tasks or researchers on the field of digital technology use and were thus seen as suitable. • Entering the field with credibility: The interviews were primarily conducted by authors of the manuscript, who were (at the time of the study) working on his/her Ph.D. thesis (thus seen in high respect in society). • Conduct of interviews: All interviews were conducted using a pre-designed interview guideline.

Quality Aspects	Quality Criteria	Authors' response to Venkatesh et al. 's (2013) guideline
Design quality	Analytical adequacy	*Qualitative (Expert Interviews and Focus Group Discussion)* • Transcription of all interviews and photo-logging of all focus group discussions; the use of interview outline (though customized for the two different types of interviews) • Each interview was analyzed by at least one author by using detailed analysis techniques and the principle of theoretical engagement (Sarker et al., 2013) and overall multiple authors participated in the analysis. • Labeling and relabeling of the relevant concepts by more than half of the authors after the generation of the codes. The process was iterative and roughly resembled a constant comparative analysis, ending when theoretical saturation occurred (Glaser & Strauss, 1967). • While no notion of interrater reliability was used, the identification and selection of the concepts represented a consensus among a great number of researchers involved in data collection and analysis, implying some form of convergence and/or reliability.
		Qualitative • Justification of the choice of analysis technique (that is, factor analysis, structural equation modeling). • A pre-test sample (n = 455), a developmental sample (n = 1,560) and a validation sample (n = 3,000) to ensure reasonable power. • The survey was randomly distributed und is representative of the German workforce ensuring that bias in a sampling of subjects is avoided or at least minimized.
Explanation quality	Qualitative inference	The constructs identified through the qualitative study were not only plausible, but many of them were seen to be relevant in the literature.
	Quantitative inference	• Internal validity concerns were addressed by developing a model that was theoretically robust, had a reliable data collection process and reliable measurements, and appropriate statistical tests. • Statistical conclusion validity, considered to be a "special case of internal validity," was ascertained by ensuring construct validity, and appropriate level of significance for tests, and testing for common method bias. • External validity was ascertained to some degree given that the sample is representative of the German workforce. In this sense, the results will likely be similar if studied in an external setting.

Quality Aspects	Quality Criteria	Authors' response to Venkatesh et al. 's (2013) guideline
	Integrative inference	Much of the originality in the study in terms of current and new digital work demands, their impacts on the negative psychological responses, and in turn on job satisfaction and productivity can be attributed to the qualitative interviews that was conducted in the introductory phase Many of the constructs that were identified in the qualitative study were empirically validated as significant in the quantitative study. An additional second-order analysis has brought further understanding of possible relationships between existing and new digital work demands. Four second-order factors were considered. Model comparisons about the structure of the twelve first-order and the four second-order factors were performed. The fit measures for the correlated group factor model were slightly better than for the second-order model. Based on the above, we can say that we have been able to achieve a reasonable degree of balance between comprehensiveness and parsimony in the model, and hence integrative efficacy. The synergy between the qualitative interviews followed by a survey, the results of which could be understood in light of the qualitative study indicates a satisfactory level of integrative efficiency and integrative efficacy.

4.14. Supplemental Material C: Combination of Search Strings in the Literature Review

Area	Specification	Search String
1 Technologies		(reality NEAR/4 (augmented OR virtual OR artificial) OR "Artificial Intelligence" OR "virtual environment") OR (digital NEAR/4 (device OR technology OR system OR machine OR assistant)) OR (technology NEAR/4 (new OR information OR communication) OR "ICT" OR robot* OR (crowd OR click OR smart) AND worker) OR (device NEAR/4 (wearable OR mobile OR smart) OR wearables OR (head NEAR/2 mounted NEAR/2 display) OR "hmd") OR (smartwatch OR smart NEAR/4 (watch OR phone OR glass*) OR mobile NEAR/4 (phone OR computing OR "based solution" OR business OR service) OR "pda") OR (tablet NEAR/2 (computer OR PC) OR touchscreen OR laptop OR notebook OR computer)

Area	Specification	Search String
2 NOT		child* OR smoking OR smoke* OR animal OR electromagnetic OR radiation OR base-station OR "base station" OR drug* OR electrosmog OR economic OR *oscopy* OR incontinence OR elastomer* OR polymer* OR *fiber* OR fabrication OR treatment OR therap* OR "PTSD" OR war OR trier OR financial OR "mechanic* stress*" OR "deformation* stress*" OR chemical* OR crystal* OR temperatur* NEAR/3 (high* OR low*) OR arthroplast* OR piezoelect* OR metal OR transistor* OR corrosion* OR microstructur* OR biomechanic* OR oxid* OR genom* OR composit* OR bone* OR diabet* OR road
3 Context		(work* OR occupation* OR job OR employ*)
A Outcome:	General and Symptoms of illness	strain OR stress OR complaint OR affliction OR distress OR irritation OR irritability OR discomfort OR disorder NEAR/4 (mood OR psychiatric OR sleep OR affect*) OR (mental NEAR/4 (illness OR symptom* OR satiation OR health OR tension OR disorder))
	Fatigue	fatigue OR exhaustion OR satiation
	Well-Being	affect* NEAR/4 (negative OR positive OR symptom* OR tension)) OR "well being" OR "well-being" OR wellbeing OR "irritable mood"
	Technostress Creators	(techno* NEAR/4 (invasion OR uncertainty OR overload OR unreliability OR complexity OR insecurity OR stress)) OR technostress OR Technikstress
	Stress Prevention	coping OR „Boundary Management" OR „online intervention" OR care OR mhealth OR "mobile health" OR mHealth OR therapy OR rehabilitation OR treatment OR screening OR "monitoring") und/oder Lernaspekte ("mobile learning" or mlearning or m-learni

4.15. Supplement Material D: Guideline for Expert Interviews (Excerpt)

Introduction	Thank you very much for taking the time to participate in this interview concerning healthy work with digital technologies. You are in expert in the field and we are kindly interested in your opinion and hearing your experiences regarding this topic.
Technology use in general	Can you think of examples of digital technologies and media which were introduced at the workplace in the last couples of years? What effect did the introduction have? *(Background information – provided upon request)* *Digital technologies (also information technology (IT), information and communication technology (ICT), information systems (IS) or just called computers) enable the storage and processing of data, the transfer of information and different types of electronically mediated communication. Digital technologies can be divided into hardware, software and networks. Hardware includes, for example, workstations, laptops, tablets, projectors or smartphones. Software includes, for example, Skype for Business, Microsoft Office, Google Drive or Dropbox. Intranet or social networks belong to the generic term of networks.*
Technostress causes	In your opinion, what causes technostress among employees? Which technologies and media may cause stress? Which characteristics or use cases of digital technologies may cause stress? (*Examples are that a technology often evolves or that the technology can be used in a flexible manner away from the workplace or outside of working hours.)* Which occupational groups are particularly affected? Do employees differ with respect to what causes technostress for example persons with different age, gender, full-time/half-time employment, care of elderly persons/children? Do employees differ with respect to what causes technostress due to their cultural background? *Background information – provided upon request)* *There are different definitions and models of stress. Stress is basically a normal and adaptive response to challenges. Stress is caused by certain triggers (stressors), e.g., excessive demands, conflicts, shift work, perfectionism. In addition, stress is associated with various reactions, such as feelings (e.g., fear, anger), behaviors (e.g., increased consumption of alcohol/nicotine, social withdrawal) and physical reactions (e.g., sweating, breathlessness), but also cognitive impairments (e.g., concentration, memory).* *However, people differ in which stressors are experienced as stressful. Whether a person experiences a situation as stressful depends heavily on how the person evaluates it, whether, for example, he sees it as personally relevant or threatening, and what "tools" or resources the person has at hand to deal with the situation. Stress does not necessarily have to be negative but can, to a certain extent, also be experienced as positive and improve performance. Stress is therefore a very individual process. In everyday language, stress often refers to the negative consequences that stressors have.* *Technostress (respectively digital stress) refers to stress that is triggered by digital technologies and is associated with certain reactions and consequences on the physical, emotional, cognitive, and behavioral level.*
Technostress consequences	In your opinion, what are the consequences of technostress for employees? How do these consequences manifest?

4.16. Supplemental Material E: Guideline for Focus Groups (Excerpt)

Instructions and questions for the group		**Comments for the facilitator**
Introduction	Today, we would like to talk about your usage of digital technologies for work. Thank you for participating in this group session. We are kindly interested in your opinions and hearing your experiences.	Keep it general Don’t name specific technologies, stressors, or consequences to avoid priming
Digital technologies	Which digital technologies do you use for work? *(Background information)* *Digital technologies (also information technology (IT), information and communication technology (ICT), information systems (IS) or just called computers) enable the storage and processing of data, the transfer of information and different types of electronically mediated communication. Digital technologies can be divided into hardware, software and networks. Hardware includes, for example, workstations, laptops, tablets, projectors or smartphones. Software includes, for example, Skype for Business, Microsoft Office, Google Drive or Dropbox. Intranet or social networks belong to the generic term of networks.*	Avoid “at the workplace” use “work” to also include mobile work Individual work (5 mins): Participants write down on cards what comes to their mind without evaluation or judgement of importance, relevance, or frequency Spread cards out on the floor, stack duplicates on top of each other, allow Discussion if it comes up
Technostress in general	How much do(es) the named technology(ies) stress you out?	Put one card per stack on the pin board Scale from *“not at all”* to “*totally*” Each participant gets sticky points for the rating to glue them on the pin board
Technostress details	What usage and/or characteristics of this specific technology stresses you out exactly?	Group discussion Comparison of triads: 2 “less stressful” technologies vs. 1 “highly stressful” technology 3 heterogeneously stressful technologies Other interesting combinations Moderator puts characteristics on pin board

4.17. Supplemental Material F: Item loadings for the Bi-Factor Model from EFA (*n*2 = 1,560)

Items	Bi-Factor	COM	INS	INT	INV	IOP	NON	LSA	OVE	PER	ROL	UNC	UNR
COM01	0.60	0.46											
COM02	0.63	0.60											
COM03	0.66	0.45											
COM04	0.60	0.51											
COM05	0.63	0.61											
INS01	0.59												
INS02	0.58		0.51										
INS03	0.64		0.54										
INS04	0.59												
INT01	0.70			0.49									
INT02	0.67			0.51									
INT03	0.71			0.56									
INV01	0.56				0.64								
INV02	0.63				0.59								
INV03	0.57												
IOP02	0.59					0.67							
IOP03	0.57					0.74							
IOP04	0.57					0.66							
NON01	0.63						0.50						
NON02	0.64						0.47						
NON03	0.50						0.67						
NON04	0.61						0.65						
NON05	0.61						0.56						
NON06	0.65						0.47						
LSA01	0.84												
LSA02	0.84							0.46					
LSA03	0.84							0.51					
LSA04	0.84							0.49					
LSA05	0.84							0.47					
LSA06	0.72												

Items	Bi-Factor	COM	INS	INT	INV	IOP	NON	LSA	OVE	PER	ROL	UNC	UNR
OVE01	0.74								0.41				
OVE02	0.71								0.46				
OVE03	0.58												
OVE04	0.71								0.46				
PER01	0.64									0.46			
PER02	0.47									0.62			
PER03	0.51									0.71			
PER04	0.63									0.56			
PER05	0.54									0.67			
PER06	0.57									0.51			
ROL01	0.74										0.42		
ROL02	0.76										0.49		
ROL03	0.76												
ROL04	0.60												
UNC01	0.46											0.61	
UNC02	0.51											0.59	
UNC03	0.44											0.69	
UNC04	0.48											0.71	
UNR01	0.55												0.64
UNR02	0.61												0.72
UNR03	0.64												0.59

Note. Loadings < 0.4 are not shown; INV = Invasion, OVE = Overload, COM = Complexity, INS = Insecurity, UNC = Uncertainty, UNR = Unreliability, ROL = Role Ambiguity, IOP = Invasion of Privacy, INT = Interruptions, PER = Performance Control, NON = Non-Availability, LSA = Lacking Sense of Achievement.

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Part III. Conclusion

1. Summary and Academic Output of the Research Papers

This dissertation adds on to current research streams about technostress. These comprise coping (e.g., Pirkkalainen et al., 2019; Tarafdar et al., 2020), stress outcomes (e.g., Chen et al., 2019; La Torre et al., 2020), technology environment condition (i.e. characteristics of technologies and the design of stress-sensitive systems) (e.g., Adam et al., 2017; Jimenez & Bregenzer, 2018; Tarafdar et al., 2019), spillover of demands into the private domain driven by technology (Benlian, 2020), and challenge vs. hindrance stressors (Benlian, 2020; Califf et al., 2020; Tarafdar et al., 2019).

Foremost, the contribution lies in the broad perspective, illuminating the phenomenon from various points of view (i.e., antecedents and consequences as well as the theoretical standpoint) considering technostress as dark side of digital transformation. The results provide insightful recommendations for organizations how to improve or retain the performance of their workforce and the company in the digital age. It meets the call by Tarafdar et al. (2019) who reviewed most important findings and elaborated still existing knowledge gaps after more than 10 years of successful research on technostress. This dissertation contributes to closing the knowledge gaps.

Tarafdar et al. (2019, p. 7) recently argued that technostress is a "continually evolving phenomenon as new types of IS […] and their use persistently emerge and reveal novel aspects of it." Accordingly Fischer et al. (2019) raise the question whether the current concept of technostress is still up-to-date. They call out "for additional quantitative investigations into the dimensionality of technostress, which acknowledges the current status of affairs" (Fischer et al., 2019, p. 1829). The presented dissertation takes all this into consideration looking at technostress from different points of view. After having carefully evaluated antecedents and consequences of technostress, it comes to the conclusion that the framework needs to be adjusted to fit the social-technical developments that evolve with progressing digital transformation. To sum up all the insights from the papers, in the last manuscript, an extension of the framework is proposed, answering the question by Fischer et al. (2019).

The findings and contribution[7] of each single paper in the dissertation are discussed below.

Research paper #1 closely relates to the technostress framework of Ayyagari et al. (2011). Within the manuscript, the technological antecedents of technostress are examined. In a mixed-methods study, qualitative data from literature search, expert interviews and focus groups, as well as quantitative data from our large PräDiTec survey was analyzed. The first contribution is the identification and definition of further characteristics of digital technologies that affect technostress at an individual's workplace, including measurement scales for the newly added characteristics. Placing these newly identified characteristics side by side with the ones from extant literature (esp. from Ayyagari et al., 2011), the paper presents the most holistic set of technology characteristics related to technostress. Further, to the best of our knowledge, we are the first to combine the characteristics of Ayyagari et al. (2011) with the technostress creators of Ragu-Nathan et al. (2008) and thereby can show their relationships. With this broader understanding of characteristics, future research can investigate the influence of digitalization on technostress in more detail. Second, we show that it is important to investigate the workplace as a whole based on the portfolio of technologies at the workplace. Prior research either investigates individual technologies (e.g., Hung et al., 2015; Maier et al., 2015; Salo et al., 2019) or the entire digital workplace without considering the individual technologies at work (e.g., Ragu-Nathan et al. 2008; Tarafdar et al. 2007). We take an intermediate way considering all major individual digital technologies at the workplace. We build technology profiles on the individuals' perception of characteristics and not by asking technology experts. Stress is a

[7] The contributions are excerpts from the research papers included in this dissertation. For better readability, I omit the separate declaration of each sentence.

construct that builds on the perception of a situation and the individual's own ability to cope with a certain situation. Therefore, from the individual's point of view, the perceived characteristics of digital technologies at the workplace are key because stress is neither solely anchored in the environment and its demands nor solely in the person characteristics (Lazarus & Folkman, 1984). Asking users rather than design experts seems appropriate according to adaptive structuration theory (DeSanctis & Poole, 1994). Third and last, we give evidence on the relationship of the characteristics with different technostress creators instead of technostress as a higher order construct based on reflective measurement of the five technostress creators. This more detailed understanding can help future research to develop specific preventive measures and coping strategies for concrete technostress creators at concrete workplaces.

Research paper #2 investigates the individual antecedents of technostress and processes behind technology-driven spillover of work into the private domain. We draw on boundary theory (Ashforth et al., 2000) from psychology, which underlines the interdisciplinarity of this dissertation. With this paper, we contribute to current research in several ways. (1) We appeal to the call by Benlian (2020) to investigate the boundary transcending effects of digital technologies and conducted a longitudinal study. By modelling the relationship between our variables at different time points, we provide first evidence for causal effects between technology adoption, technostress and its spillover effects causing role conflict. The results further provide insights on technology adoption. In this context several models are discussed in research which try to explain what leads to acceptance of different technologies and their adoption. The most recognized one is probably the Technology Acceptance Model (TAM) by Davis et al. (1989). Different expansions of the model have been proposed (Venkatesh et al., 2003). While these models include many individual characteristics like hedonic motivation, expectations of effort and performance, age, gender etc. (Venkatesh et al., 2003), we found another factor that directly influences adoption of technologies. Segmentation preference as a stable individual trait adds on to the list of factors which is related to technology use behavior. Additionally, it is examined how technology environment conditions lead to technostress in different ways depending on an individual trait segmentation preference. Thereby the paper contributes to the current discourse about challenge and hindrance stressors and different outcomes of technostress as discussed by Tarafdar et al. (2019).

Research paper #3 looks at consequences of technostress contributing to the current research stream on coping (e.g., Pirkkalainen et al., 2019; Tarafdar et al., 2020), answering the call by Tarafdar et al. (2019) for further inter-disciplinary technostress research. Our research provides three important contributions to research on technostress and coping, namely: (1) investigating the influence of technostress and coping on organizational and individual-level outcomes; (2) modeling coping as a moderator applying the workplace-specific JD-R model as a meta-lens; and (3) emphasize the importance of the distinction between functional and dysfunctional coping of technostress concerning organizational and individual-level outcomes. The manuscript addresses the call by Sarker et al. (2019) that most manuscripts in high-quality journals are concerned merely with the organizational outcomes. In a socio-technical system – i.e., a system focusing on the reciprocal interaction between technology as the technical component and the employee as the social component (Lee et al., 2015; Ryan et al., 2002) - it is important to consider both organizational and individual-level outcomes to create synergies (Griffith et al., 1998; Pava, 1983; Wallace et al., 2004). Therefore, our research addresses the influence of functional and dysfunctional coping on both organizational (productivity) and individual-level outcomes (exhaustion). Furthermore, in the context of technostress, we have applied the JD-R model as a theoretical meta-lens, in which both organizational and individual-level outcomes play a key role and which has not been applied in this context before (Bondanini et al., 2020). We modeled coping as a moderator which was done in recently published studies on coping and technostress (Nisafani et al., 2020; Pirkkalainen et al., 2019) independently from the theoretical anchor of the JD-R model. This emphasizes the difference to "coping […] as a mediator of short-term emotional reactions" known from Lazarus and Folkman (1987, p. 147). In addition, we also distinguished the specific nature of coping and examined the influence of different coping styles. Thus, we extend recent literature (Nisafani et al., 2020; Pirkkalainen et al., 2019) focused on a distinction between proactive coping (i.e., strengthening one's ability to cope) and reactive coping, neglecting the different types of reactive coping. Dysfunctional coping like alcohol or drug consumption as a reactive form of coping has not been thoroughly investigated. For example, addiction in the context of ICT use is most salient in behavioral addiction like consumption of pornography or extensive gaming (Tarafdar et al., 2020) while there is less focus on substance abuse. We were able to provide evidence that this aspect should not be neglected in IS research.

Research paper #4 completes the big picture. Our research evaluates the current concept of technostress and its' creating factors in the context of contemporary digital work practices. It aligns with Tarafdar et al. (2019, p. 7) who suggested that stress induced by digital technologies is a continually evolving phenomenon with ongoing digitalization. Further, we gave answer to the question brought up by Fischer et al. (2019), whether the measurement instrument of technostress is still up to date. Against this background, our research makes the following four contributions. First, we present a holistic set of the most important digital work demands. Nine of these twelve demands were considered in technostress literature before, for example, Tarafdar et al. (2007), Ragu-Nathan et al. (2008), Ayyagari et al. (2011), and Galluch et al. (2015). Further, we added three additional digital work demands that tax or potentially exceed workers' resources, creating stress: non-availability, performance control, and lacking sense of achievement. We combined them in a single unified model. Second, empirical evidence and theoretical reasoning bring to light a higher-order structure with four second-order demands from digital work. Prior research has already considered higher-order models (e.g., Ragu-

Nathan et al., 2008; Tarafdar et al., 2007, and research building on these articles). Yet, it suggested a single unitary second-order factor. With the context of contemporary work practices, our substantially broader conceptualization of digital work demands and our large empirical samples, we see that the structure is multi-faceted. Hence, we newly introduce the second-order demands impediment, interference, constant change, and exposure. By adding much needed further dimensions and expanding the concept of technostress from originally five to twelve dimensions, we believe that this hierarchical structure will be helpful in understanding the increasing complexity and identifying links between such dimensions. Third, we suggest evolving the concept of technostress to digital stress. Because of its broader definition, a theory of digital stress as an extension of technostress can consider more aspects of modern private and professional use of technology by individuals over a life span from young to elderly. By doing so, such a theory of digital stress may contribute to terminologically unitizing the multidisciplinary research field of technology-induced stress. Fourth, we developed and validated survey-based measurement scales for the newly identified constructs along the way of developing the first and second contributions. Further, we validated the compatibility and delineation of these scales with established digital work demands. These scales may be used in future research to measure digital work demands.

2. Individual Contribution to the Included Research Papers

This is a cumulative dissertation. The included papers are published or are currently under revision in reputed academic journals or conference proceedings with a peer review process. They were written in different constellations of authors from several institutions. In the following, I will lay open my individual contribution to each article.

Research paper #1 was written in a team of five authors. The idea for the manuscript which is presented in Part II.1, was brought up by my colleagues from PräDiTec (Michelle Berger, Julia Lanzl, and Christian Regal) and their supervisor, Prof. Dr. Henner Gimpel. I eagerly joined their team and advanced its submission, serving as corresponding author. Within the research process, I substantially contributed to each stage, always supported by my co-authors. I was considerably involved in the design of the research, the data collection, the storyline of the paper, the literature review, as well as the conceptualization, the analysis of data and the writing of all chapters. Further, I contributed to the revision during the submission process. The final manuscript was presented at the virtual conference by Michelle Berger and Julia Lanzl. Henner Gimpel was involved by giving constant feedback for improvement of the manuscript to successful submission in the Proceedings of the 41th International Conference on Information Systems.

Research Paper # 2 was written in a team of two. For the second manuscript presented in Part II.2, I again joined forces with Julia Lanzl. Data was collected within in the context of PräDiTec by the colleagues from Fraunhofer FIT. I was involved in this step by giving feedback on the selected scales and constructs. As the corresponding and lead author, I was responsible for the research idea, its' conceptualization, and the design of the storyline. Further, I was also centrally involved in the literature review, the data analysis and the writing of all the chapters. Julia Lanzl greatly supported me with feedback and input and was also involved in designing the storyline and writing the text. The manuscript is submitted to Information & Management.

Research paper # 3, which is presented in Part II.3 was written in a team of four authors. I was the lead author that brought up the idea for the research on coping and technostress. As an expert for stress and coping Torsten M. Kühlmann advised us during the complete preparation of the manuscript, giving valuable feedback on the storyline and theory. I substantially shaped the manuscript being involved in all stages of the research process. This included the data collection, the conceptualization, the development of a storyline as well as the literature review, and theory. Further I was responsible for data analysis and the writing of text. Nicholas Daniel

Derra supported the development of the story line, gave feedback on analysis, and was involved in the writing. Christian Regal also support the writing and the data analysis. Additionally, they were both involved in the editing during the revision process. The manuscript is published in the Journal of Decision Systems.

Research paper # 4 was written in a team composed of eight authors. Together, the project team in PräDiTec shaped the idea for writing this article included in Part II.4 of the dissertation. Here, I was also involved in all stages of the research process, including data collection, story line, literature review, conceptualization, data analysis and the writing itself. Henner Gimpel was leading and overseeing the preparation process of the manuscript together with Torsten M. Kühlmann, Patricia Tegtmeier, and Nils Urbach. As experienced researchers they provided detailed feedback on the storyline and manuscript overall improving its' quality and offering guidance in the publication process. Further Mathias Certa, Julia Lanzl and Christian Regal supported and contributed to all stages of the preparation of this article together with me. The manuscript is submitted to MIS Quarterly.

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