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ORIGINAL ARTICLE

Technostress mitigation: an experimental study of social support during a computer freeze

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Abstract
In situations when Information Systems (IS) do not work as intended, using IS might hinder their users and let them perceive technostress; this then comes along with reduced user performance and high perceptions of exhaustion, among others. To alleviate these consequences, a mitigating behavior of stressed users is to seek social support to get instrumental (e.g., from the help desk) or emotional (e.g., consolation) backing. Using insights from psychology literature that suggest social support reduces the consequences of stressors, this paper investigates how instrumental and emotional support reduces the consequences of techno-stressors, such as reduced end-user performance, techno-exhaustion, and physiological arousal, caused by techno-unreliability such as a computer freeze. In a laboratory setting, measurements of skin conductance were used to evaluate the technostress of 73 subjects, manipulated by techno-unreliability and then treated with instrumental and emotional support. The findings indicate that social support increased end-user performance as well as reduced techno-exhaustion and physiological arousal. In particular, instrumental support directly influenced end-user performance, techno-exhaustion, and physiological arousal, whereas emotional support only influenced techno-exhaustion. Further, this study provides the first indications that the effect of social support on technostress depends on individual differences.

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1 Introduction

Information systems (IS) that do not work as they should can hinder users and create technostress (Ragu-Nathan et al. 2008). Users then take countermeasures (Tarafdar et al. 2019a). One countermeasure is seeking support from others (e.g., Beaudry and Pinsonneault 2010; Liang et al. 2019). When the IS shows an error or crashes, users seek help from friends, family, or co-workers. This support from others can change their evaluation of the situation such that users see it more positively than they did initially (Beaudry and Pinsonneault 2010; Folkman et al. 1986). Hence, the act of seeking support might be a crucial ingredient in ensuring well-being and fostering progress and sustainable performance. In 2019, organizations worldwide were expected to spend up to $168.2 billion on support services (Statista 2019). While these investments are at an all-time high, technostress is still on the rise and challenges users day-in-day-out (Maier et al. 2015b; Salo et al. 2019). It is hence relevant to understand how different types of support reduce perceptions of technostress and, as a consequence, improve the well-being and performance of users.

While research on technostress has mostly studied the antecedents of techno-stressors, e.g., technological characteristics (Ayyagari et al. 2011) and predispositions (Maier et al. 2019), or the consequences of techno-stressors, e.g., low end-user performance, psychological exhaustion, and physiological arousal (Maier et al. 2015b; Tams et al. 2014; Tarafdar et al. 2015b), there is very little research about remedies or factors mitigating the perceptions of technostress (e.g., Pirkkalainen et al. 2019; Tarafdar et al. 2019b). Some research has considered technostress mitigation as a mechanism that reduces techno-stressors or their consequences (Salo et al. 2017). Psychology research has long suggested that users seek social support (Carver et al. 1989; Lazarus and Folkman 1984) to receive emotional consolation or instrumental aid from others to mitigate stressful situations (Weiss 1983). In particular, psychological literature distinguishes between emotional and instrumental support (Taylor 2011). *Instrumental support* is task-related help to get the job done (Beehr et al. 2000). *Emotional support* by others provides warmth, nurturance, and care to stressed users (Taylor 2011). While it is commonly known that these two types exist, their effects on technostress remain a black box. Thus, this paper aims at contributing to the technostress literature by disclosing how instrumental and emotional support can mitigate the consequences of techno-stressors. Hence, even though organizations spend a considerable amount of money on support structures, it is currently unknown whether providing instrumental or emotional support reduces the negative consequences resulting from the perception of a techno-stressor. Based on this practical relevance, the research question is:

> *How do different types of social support (i.e., instrumental and emotional support) mitigate the consequences of techno-stressors?*

To answer this research question, a research model was developed to investigate how two types of social support (e.g., instrumental and emotional support) influence the behavioral, psychological, or physiological consequences of techno-stressors, i.e., the primary responses to techno-stressors (Cooper et al. 2001; Maier et al. 2019). Based on previous literature, these consequences are operationalized as end-user performance as a behavioral consequence (Maier et al. 2019), techno-exhaustion as a psychological consequence (Ayyagari et al. 2011), and physiological arousal as a physiological consequence (Riedl 2013; Tams et al. 2014). To validate the research model, a laboratory experiment was conducted where the users were treated with instrumental or emotional support while stressed due to the work with information technology (IT). As a result, the paper contributes to the literature by investigating the effect of instrumental and emotional support on the consequences of techno-stressors (e.g., end-user performance, techno-exhaustion, physiological arousal).

The paper is organized as follows. First, technostress and technostress mitigation are described. Subsequently, the hypotheses are developed, and the research model and the methodology of the laboratory experiment are explained. Then, the resulting data are analyzed and the findings presented. Finally, the contributions of the research to the literature, its limitations, as well as directions for future research are discussed.

2 Theoretical background

The following description of the theoretical foundation explains technostress, introduces three different consequences of techno-stressors, and explains technostress mitigation. Subsequently, the different types of social support are explained before developing a theoretical model of technostress mitigation.

2.1 Technostress

Technostress is defined as the perception of stress while using IT (Tarafdar et al. 2019a). Technostress research has focused either on chronic technostress, a general stress related to an ongoing situation over a more extended period of time, or episodic technostress, stress related to the performance of a specific task over a short period of time (Maier et al. 2019). In both cases, technostress should be understood as an umbrella term comprising techno-stressors as well as their consequences (Ragu-Nathan et al. 2008).

Techno-stressors are technology-related stimuli appraised by the user as damaging or threatening (Tarafdar et al. 2019a). Several techno-stressors have been examined, although most of the technostress research focuses on chronic techno-stressors (see Appendix Table 11 for an overview). Among the chronic technostress research concentrates on techno-stressors more chronic in nature, which means that users are exposed to techno-stressors over a more extended period (e.g., techno-invasion, work-home conflict, or role ambiguity) (Ragu-Nathan et al. 2008; Tarafdar et al. 2010).

Episodic technostress research considers techno-stressors to be more acute in nature, which means that users perceive a techno-stressor as a current IT-driven stimulus for a short time period (e.g., computer breakdown, interruptions; Riedl et al. 2012). These acute techno-stressors are also called interruption-based techno-stressors and have been investigated in prior research (Galluch et al. 2015; Riedl et al. 2012; Tams et al. 2014, 2018). One significant instance of an acute techno-stressor is techno-unreliability (Adams et al. 2014; Fischer and Riedl 2015). Techno-unreliability is understood as IT malfunctions and other IT hassles (Adams et al. 2014). In particular, techno-unreliability is the instability that comes from IT malfunctioning, failure, breaking down, and delay in computing, which prevents users from entirely being able to rely on the IT they use (Fischer and Riedl 2015). The present paper focuses on acute techno-stressors because the majority of the technostress literature has neglected these; a further objective of the paper is the investigation of the mitigation of various consequences of techno-stressors by measuring their physiological consequences, which might not be possible when investigating chronic techno-stressors.

The consequences of techno-stressors are called *strain* responses and can be behavioral, psychological, or physiological (Cooper et al. 2001; Maier et al. 2019).[1] These strain responses take place when users are confronted with episodic (Riedl et al. 2012) as well as chronic (Ragu-Nathan et al. 2008; Tarafdar et al. 2010) techno-stressors.

Behavioral strains include behavioral responses to the techno-stressor. These include behaviors such as lower performance levels, mistakes, errors, absenteeism, and turnover (Cooper et al. 2001; Tarafdar et al. 2010). From an organizational point of view, this strain response is quite crucial because it can result in substantial costs to organizations (Cooper et al. 2001). A remarkable instance of behavioral strain, which also has been intensively studied in previous technostress literature, is reduced end-user performance (Maier et al. 2019; Tams et al. 2018; Tarafdar et al. 2010), which usually represents how fast and accurately users fulfill their tasks while working with IT (Gattiker and Goodhue 2005).

Psychological strains reflect the state of mind at a conscious level (Tams et al. 2014). This strain response includes psychological reactions to the techno-stressor (Maier et al. 2019). Different reactions have been examined in the previous literature such as job and user satisfaction (Ragu-Nathan et al. 2008; Tarafdar et al. 2010), burnout (Maier et al. 2019; Srivastava et al. 2015), or IT addiction (Tarafdar et al. 2019b). However, most of these earlier investigations interpret psychological strain as techno-exhaustion (Ayyagari et al. 2011; Maier et al. 2014, 2015b; Tams et al. 2014). Ayyagari et al. (2011) argue that techno-exhaustion is the main psychological response studied in technostress research; techno-exhaustion is defined as the feeling of tension and depletion of one's emotional resources (Maslach et al. 2001; Moore 2000), i.e., drained, tired, fatigued, or frustrated as the results of working with IT (Ayyagari et al. 2011).

Physiological strains include bodily responses to stressors such as cardiovascular, biochemical, and gastrointestinal symptoms (Cooper et al. 2001) and have been the subject of recent investigations of users' biological responses to especially acute techno-stressors (Riedl et al. 2012; Riedl 2013). This response is based on two major stress systems in the brain: the autonomous nervous system (ANS) and the hypothala-

[1] These strain responses are also called job-related negative outcomes (behavioral strain), well-being–related negative outcomes (psychological strain), and physiological outcomes (physiological arousal) (Tarafdar et al. 2019a).

mus–pituitary–adrenal axis (the HPA axis). The HPA axis plays a primary role in the body's reactions to techno-stressors by balancing hormones released by the adrenaline-producing adrenal medulla and the corticosteroid-producing adrenal cortex (Riedl 2013). The activation of the ANS leads to emotional sweating, pupil dilation, a faster heartbeat as well as an increase in the cortisol level (Riedl 2013).

Unlike psychological strain, physiological strain may be experienced at an unconscious level (see Riedl (2013) for an extensive description of physiological strain). The results of previous studies indicate that psychological strain often does not correlate with physiological responses (Riedl 2013). In other words, psychological strain reflecting an emotional state is often different from physiological strain, including bodily responses to techno-stressors. Also, psychological and physiological strains are influenced by different antecedents. Psychological strain is caused by the interaction between demands and an individual's conscious assessment of those demands, whereas physiological strain is directly caused by environmental stimuli (Tams et al. 2014). There is evidence that psychological and physiological strains in a technostress context are distinct responses (Riedl 2013; Tams et al. 2014). Moreover, physiological strain is associated with negative well-being and health, such that techno-stressors may lead to serious health damages (Riedl 2013). One example of physiological strain studied in the previous technostress literature is physiological arousal (Riedl et al. 2012; Riedl 2013; Tams et al. 2014), defined as the activation of different physiological systems such as CNS and subsequently occurring peripheral adaptive responses such as emotional sweat.

Taken together, the previous technostress literature demonstrates that the perception of acute techno-stressors, such as techno-unreliability, leads to behavioral, psychological, and especially to physiological strain. In this context, prior research mostly focuses on behavioral strain in terms of reduced end-user performance, psychological strain in terms of techno-exhaustion, and physiological strain in terms of arousal. Besides the factors which trigger these strain responses, there also exist factors that mitigate these strain responses, which are explained next.

2.2 Technostress mitigation

The technostress literature has examined technostress mitigation from two different perspectives—the organizational and the individual perspective. The first, the organizational perspective, draws on organization literature and examines mechanisms that can be taken by organizations to reduce the technostress of individuals (Ragu-Nathan et al. 2008). The second, the individual perspective, draws on coping theory (Lazarus and Folkman 1984) and investigates how users themselves aim to reduce technostress by deploying behavioral, cognitive, and perceptional efforts. Both perspectives are explained in the following.

2.2.1 Organizational perspective on technostress mitigation

The organizational perspective identifies technostress inhibitors, which are organizational mechanisms that reduce technostress (see Ragu-Nathan et al. 2008; Tarafdar

Table 1 Related work on organizational mitigation of technostress

Authors	Mitigation	Dependent variable	Results
Ragu-Nathan et al. (2008)	Technostress inhibitors[a] (literacy facilitation, technical support provision, involvement facilitation)	Job satisfaction	Technostress inhibitors increase job satisfaction
		Organizational commitment	Technostress inhibitors increase organizational commitment
		Continuance commitment	Technostress inhibitors increase continuance commitment
Tarafdar et al. (2010)	Innovation support	End-user satisfaction	Innovation support increases end-user satisfaction
		Innovation facilitation	Innovation support increases innovation facilitation
	Innovation facilitation	End-user performance	Innovation facilitation increases end-user performance
		Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	Innovation facilitation decreases techno-stressors
Tarafdar et al. (2011)	Technostress inhibitors[a] (technical support provision, technology involvement facilitation, innovation support)	Job satisfaction	Technostress inhibitors increase job satisfaction
		Organizational commitment	Technostress inhibitors increase organizational commitment
		Role conflict	Technostress inhibitors decrease role conflict
		Role overload	Technostress inhibitors decrease role overload
		Employee innovation	Technostress inhibitors increase employee innovation
		Employee productivity	Technostress inhibitors increase employee productivity
		End-user satisfaction	Technostress inhibitors increase end-user satisfaction

Table 1 continued

Authors	Mitigation	Dependent variable	Results
Tarafdar et al. (2015b)	Technostress inhibitors[a] (technical support provision, technology involvement facilitation, innovation support)	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	Technostress inhibitors decrease techno-stressors
Fuglseth and Sørebø (2014)	Technostress inhibitors[a] (involvement, support, literacy)	Satisfaction	Technostress inhibitors increase satisfaction
		Intention to extend the use of ICT	Technostress inhibitors have no significant effect on intention

[a]Second-order construct

et al. 2010), including a conglomerate of different organizational mechanisms such as technical support provision, literacy facilitation, and involvement facilitation (Ragu-Nathan et al. 2008).

Table 1 summarizes related studies, which all take the organizational perspective on technostress mitigation. From very early on, technostress research has concentrated on organizational mechanisms reducing technostress (called technostress inhibitors), such as technical support provision, literacy facilitation, and involvement facilitation (Ragu-Nathan et al. 2008), for instance, whether good technical support in terms of a knowledgeable and easily accessible help desk provided by the organization reduces the technostress level of the employees. Thereby, technical support provision guides the user on how to use new systems, which reduces anxiety. Involvement and literacy facilitation include the user in the planning and implementation phase of an IS to consider how the system will be used and to address all of the users' requirements. The findings reveal that technostress inhibitors reduce strain responses, increasing job satisfaction, organizational commitment, and continuance commitment (Ragu-Nathan et al. 2008). A similar study (Tarafdar et al. 2011) shows that technostress inhibitors reduce techno-stressors and increase job and end-user satisfaction, organizational commitment, innovation, and productivity and reduce role conflict and overload.

Another study (Tarafdar et al. 2010) focuses on technostress inhibitors comprising involvement facilitation and innovation support. Involvement facilitations describes mechanisms where users are encouraged to use new IT via rewards and consultation. Innovation support represents a mechanism that provides help to develop new ideas and facilitates the learning process. The study theorizes that involvement facilitation decreases techno-stressors and user satisfaction, whereas innovation support is only positively related to user satisfaction. In more recent studies, technostress inhibitors encompassing technical support provision, literacy facilitation, and involvement facilitation decrease the perception of techno-stressors and increase technology-enabled innovation (Tarafdar et al. 2015b) as well as satisfaction (Fuglseth and Sørebø 2014).

2.2.2 Individual perspectives on technostress mitigation

Some studies have investigated the individual perspective on technostress mitigation based on psychological coping theory (Lazarus and Folkman 1984). This perspective shows that individuals cognitively evaluate the perception of techno-stressors to decide what to do to mitigate their consequences towards techno-stressor (Tarafdar et al. 2019a). The psychological literature demonstrates that users try to mitigate stressful situations by either focusing on the direct problem, such as seeking instrumental support, or by trying to regulate their negative emotions that are tied to the stressful situation by, for instance, seeking emotional support (Folkman et al. 1986; Lazarus 1999; Lazarus and Folkman 1984). The literature posits that mitigation mechanisms reduce either the techno-stressors, the relation between techno-stressors and strain responses, or the strain responses directly (Pirkkalainen et al. 2019; Salo et al. 2017).

Table 2 summarizes the works examining individual technostress mitigation mechanisms. Weinert et al. (2013) developed a conceptual model of individual technostress and mitigation. They theorized that problem- and emotion-focused mitigations reduce technostress. In particular, they assumed that technostress mitigation moderates the relationship between techno-stressors and strain responses. Galluch et al. (2015) suggest that mitigation mechanisms such as method and resource control moderate the relationship between overload and conflict and psychological and physiological strain responses. Method control allows users to control the way they use IT to accomplish their work tasks. Resource control allows users to break from a stressful situation. No effects were found on the relationship between overload and conflict and psychological responses, whereas resource control decreased the relationship between overload and physiological responses, and method control decreased the relationship between conflict and physiological responses.

Recent technostress research (Pirkkalainen et al. 2017) examines whether distress venting and distancing from IT mitigates the effect of techno-stressors on techno-exhaustion. By distress venting, users are able to let their feelings out when an IT problem occurs. Distancing oneself from IT considers that the users avoid IT. The study investigates the role of IT control in this context. The results indicate that distress venting reduces the effect of techno-stressors on techno-exhaustion but only when users have low IT control. In addition, the findings show that distress venting has a direct positive effect on techno-exhaustion such that the higher the distress venting, the higher the techno-exhaustion.

The technostress concept has been extended to the domain of IT security. One study (D'Arcy et al. 2014) investigated overload, complexity, and uncertainty, which creates stress in employees. It is theorized that security-related stress (SRS) influences information security policy (ISP) violations and that mitigation mechanisms mediate this relationship. The results showed that moral disengagement increased ISP violation intentions significantly and indicated that moral disengagement plays a mediating role between SRS and ISP violation intention. A recent paper (Pirkkalainen et al. 2019) considers the effect of deliberate proactive and instinctive reactive coping and technostress. The investigation states that reactive coping in terms of distress venting and distancing from IT can reduce the effect of techno-stressors on productivity, whereas

Table 2 Related work on individual mitigation of technostress

Authors	Mitigation	Dependent variable	Results
Weinert et al. (2013)	Emotion-focused coping Problem-focused coping	Relation between techno-stressor and strain	–
D'Arcy et al. (2014)	Moral disengagement	ISP-violating behavior	Moral disengagement increases the information security policy violation intention, and it mediates the relationship between security-related stress and information security policy violation intention
Galluch et al. (2015)	Method control	Physiological strain responses (alpha-amylase)	Method control (a) increases the relationship between overload (b) decrease the relationship between conflict and physiological strain responses (alpha-amylase)
	Resource control	Physiological strain responses (alpha-amylase)	Resource control (a) decreases the relationship between overload (b) increases the relationship between conflict and physiological strain responses (alpha-amylase)
Pirkkalainen et al. (2017)	Distress venting	Technostress creators (overload, invasion, complexity, insecurity, uncertainty)	Distress venting reduces the relation between technostress creators and techno-exhaustion and increases techno-exhaustion directly
	Distancing from IT	Techno-exhaustion	Distancing from IT has no significant effect

Table 2 continued

Authors	Mitigation	Dependent variable	Results
Salo et al. (2017)	Stressor reduction (modification of IT features and routines) Stressor toleration (Modification of personal reactions to IT stressors) Recovery from strain (Temporary disengagement from IT, online/offline venting)	Techno-stressors, Relation between techno-stressors and strain responses, strain responses	–
Weinert et al. (2019)	Active coping Mental disengagement	–	–
Pirkkalainen et al. (2019)	Distancing from IT Distress venting Positive reinterpretation IT control	IT-enabled productivity	Distancing from IT influences the relation between techno-stressor and IT-enabled productivity. This effect is moderated by positive reinterpretation and IT control
Tarafdar et al. (2019b)	Distraction within SNS Distraction outside SNS	IT addiction	Distraction within SNS increases IT addiction. Distraction outside SNS has no significant effect on IT addiction

[a]Second-order construct

proactive coping in terms of positive reinterpretation influences reactive coping and directly influences productivity.

Tarafdar et al. (2019b) concentrate on distraction as a coping strategy within an social networking sites (SNS) context. Two different types of distractions are considered: 'distraction through use of the same SNS' and 'distraction through activities outside the use of the SNS.' Their results showed that techno-stressor active users to cope in terms of distraction either with using other features within the same IT or with other activities, whereas 'distraction through the use of the same SNS' increases SNS addiction.

Taken together, technostress mitigation research takes two perspectives: the organizational perspective, which considers mechanisms that can be used by organizations to reduce technostress, and the individual perspective which examines the behavioral, cognitive, and perceptional efforts a user takes to reduces technostress. However, the effect of social support has been neglected within both perspectives. Conversely, support structures have been investigated as part of a conglomerate of organization mitigation mechanisms (e.g., technostress inhibitors). In this case, the mitigation effect of support structures of an organization in terms of the knowledgeability and availability of the help desk has been investigated.

However, social support has not yet been investigated by considering the individual perspective of technostress mitigation. The direct effect of how emotional concern and instrumental aid from other people help to reduce technostress is currently unknown. Furthermore, the psychological literature indicates that different types of social support exist, which have been disregarded in the technostress context. To fill the gap, the literature on social support is outlined, and the differences between the two types of social support—instrumental and emotional support—are explained next.

2.2.3 Social support: Instrumental and emotional support

Social support *"is defined as a flow of emotional concern [and] instrumental aid [...] between people"* (Weiss 1983, p. 31). Someone who receives social support experiences or perceives that one is cared about by others, esteemed and valued by others, and part of a network of people exchanging mutual help and obligations (Wills 1985). Social support might come from different sources, such as a partner, relative, friend, or coworker (Allen et al. 2002).

Psychological research suggests that social support is especially essential for users in stressful situations (Cohen and Wills 1985). Social support can influence the assessment of the environment by providing support for the process of appraising the situation or by directly influencing the strain responses to the situation (Cohen and Wills 1985). The literature consistently shows that social support decreases negative strain responses in stressful life situations (Taylor 2011), recognizes the relationship between health and social support (Langford et al. 1997), and claims that it is one of the most significant predictors of health and reduces negative health consequences (McCorkle et al. 2008; Yan and Tan 2014).

Extant psychological research has identified instrumental and emotional support[2] as two different types of social support (Taylor 2011). As mentioned above, mitigation literature demonstrates that two main categories of mitigation exist—problem- and emotion-focused mitigation (Lazarus 1999; Lazarus and Folkman 1984). Problem-focused mitigation focuses on the direct problem and offers instrumental support. Emotion-focused mitigation intends to regulate emotions tight to the situation and offers emotional support (Lazarus 1993). In other words, users draw on instrumental support to receive help from colleagues and on emotional support to receive sympathy, understanding, and encouragement to restore emotional stability so as to be able to face the stressful situation.

[2] According to Cohen and Wills (1985), instrumental support has also been referred to as aid, material support, and tangible support, and emotional support has also been referred to as esteem support, expressive support, self-esteem support, ventilation, and close support. Moreover, other types of support exist, such as companionship or information support, which have not been considered in the present research.

Instrumental support[3] is defined as help by co-workers and supervisors to get a job done (Beehr et al. 2000). It includes the provision of financial or tangible assistance, such as services and other specific help (Taylor 2011). Examples include driving an injured friend to the emergency room or helping a coworker by solving an IT-related issue. Instrumental support may help reduce strain responses by directly resolving the perceived issue (Cohen and McKay 1984). For example, in the context of IT use, a user struggling with a computer freeze gets help or advice about what to do to fix the computer.

Emotional support is defined as "*warmth and nurturance to another individual and reassuring a person that he or she is a valuable person for whom others care*" (Taylor 2011, p. 193). Emotional support is the sharing of happiness or showing care and concern. It sends a signal that the individual is not alone, that one is taken care of and valued (Yan and Tan 2014). Receiving sympathy from colleagues, friends, and relatives helps overcome negative situations (Beaudry and Pinsonneault 2010). For instance, in the context of IT use, a user struggling with a computer freeze can restore their emotions by talking with a friend or a coworker about the problem, and the coworker provides emotional endorsement.

In summary, there are two main mitigation effects (i.e., problem- and emotion-focused) for users in stressful situations (Lazarus and Folkman 1984). In line with these main mitigating effects, this study focuses on instrumental support as an instance of problem-focused mitigation and emotional support as an instance of emotion-focused mitigation and their influences on the strain responses. In the following, the research model is developed.

3 Hypotheses development

In the following, the research model is developed. The model focuses first on the antecedents of technostress and theorizes that techno-unreliability leads to reduced end-user performance, higher techno-exhaustion, and especially to higher physiological arousal.

Second, the mitigation effects of social support are hypothesized. The technostress mitigation literature demonstrates that mitigation activities reduce either the techno-stressor, the relation between the techno-stressor and the strain responses, or the strain responses directly (Salo et al. 2017). As shown in Table 2, previous investigations focus either on the indirect (Galluch et al. 2015; Pirkkalainen et al. 2017, 2019) or direct (D'Arcy et al. 2014; Pirkkalainen et al. 2019; Tarafdar et al. 2015b, 2019b) effect of technostress mitigation. As the present paper investigates an episodical technostress situation with acute techno-stressors and strain responses which result within in a few seconds rather than minutes (e.g., physiological arousal), the direct mitigation

[3] Technical support provision has been investigated before in the technostress literature (Ragu-Nathan et al. 2008; Tarafdar et al. 2015b), however, these papers focus on an organizational perspective by examining how the support structures of an organization reduces technostress instead of looking on the real effect of support from other individuals, which is the focus of the present paper.

effect is primarily considered because this effect aims to mitigate the consequences of techno-stressors once they have already occurred (Salo et al. 2017). In other words, in an episodical technostress situation, strain responses occur instantaneously such that users are forced to mitigate the consequences of the techno-stressors. The direct effect can thereby be problem- and emotion-focused. For example, users can vent and swear to release emotional tension caused by IT (Salo et al. 2017) or seek instrumental counseling (Langford et al. 1997). Moreover, looking especially on social support, the past literature suggests that social support has a direct effect on strain responses even in non-stressful times (Taylor 2011). Therefore, this paper assumes that the two different types of social support, i.e., instrumental and emotional support, directly increase end-user performance, reduce techno-exhaustion, and physiological arousal (see Fig. 1).

Lastly, the influences of different control variables are explained herein because the previous literature (Taylor 2011) indicates that individual differences (e.g., gender, age, IT experience, and IT self-efficacy) might influence the effect of social support.

3.1 The impact of techno-unreliability on end-user performance, techno-exhaustion and physiological arousal

Prior research indicates that techno-stressors lead to a decrease in end-user performance (Maier et al. 2019; Tarafdar et al. 2010, 2015b). Users frequently experience unreliable IT during their daily tasks (Butler and Gray 2006), and their performance often worsens as a result. For example, when users have to repeat work due to undependable IT or when their workload increases due to actions taken out of fear of techno-unreliability (Ayyagari et al. 2011), their performance might decline. When perceiving a techno-stressor, users tend to evaluate themselves negatively, which leads to a self-evaluative feeling of incompetence and lack of achievement; people feel unhappy and dissatisfied with their accomplishments (Maslach et al. 2001), which may lead to lower performance. When the computer is undependable and does not respond appropriately (e.g., computer freezes), organizational demands exceed users' abilities, which leads to lower performance by the user (H1a).

Past technostress research shows that users confronted with techno-stressors face techno-exhaustion (Ayyagari et al. 2011; Maier et al. 2014, 2015b; Tams et al. 2014). Software and hardware errors, quality problems, and general failures cannot be avoided (Lee et al. 2017). As a result, the perception of an unreliable IT leads to techno-exhaustion because users cannot perform their daily tasks, which leads to tension and depletion of one's emotional resources. As a consequence, a user is not able to perform her work, which leads to feelings of tiredness and fatigue (H1b).

When technology usage is perceived as stressful, users react not only psychologically but physiologically (Riedl 2013). Evidence shows that techno-stressors such as techno-unreliability lead to elevated cortisol levels (Riedl et al. 2012) and increased skin conductance (SC) (Eckhardt et al. 2012; Riedl et al. 2013). Techno-stressors activate several physiological mechanisms in the endocrine system, the central nervous system, and the autonomic nervous system (Riedl 2013). Techno-stressors influence physiology in several ways, including through specific affective and cognitive pro-

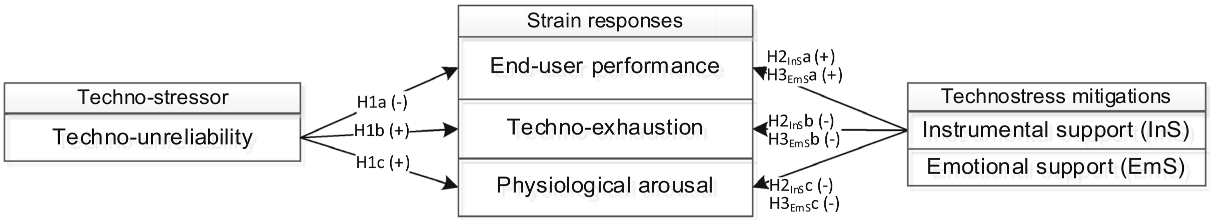


Fig. 1 Research model

cesses and underlying brain mechanisms (Riedl et al. 2012). Sensory information regarding a perceived techno-stressor such as techno-unreliability is processed in the thalamus and, in particular, in the frontal cortex. After that, the brain subconsciously evaluates the significance of a stimulus in a particular context, and this assessment may lead to the generation of a response (Riedl et al. 2012). In other words, this activation leads to physiological arousal, measurable as a higher heart rate, blood pressure, SC, and hormone levels (e.g., adrenaline and cortisol; Riedl 2013). Regarding SC, techno-stressors can cause an increase in the activity of sweat glands (Randolph et al. 2005) (H1c).

> *H1: Users who experience unreliable IT (a) have lower end-user performance, (b) are more techno-exhausted, and (c) are more physiologically aroused than those who do not perceive techno-unreliability.*

3.2 The impact of instrumental support on end-user performance, techno-exhaustion and physiological arousal

When receiving assistance from co-workers, performance levels that had slipped due to techno-stressors may be restored because the instrumental support from co-workers helps to remove the techno-stressor and users feel more motivated when they receive instrumental support (Van Yperen and Hagedoorn 2003). The literature shows that instrumental support increases satisfaction (Ragu-Nathan et al. 2008). For instance, in a situation where a user is registering invoices using IT and the computer is undependable and does not respond properly (e.g., the computer freezes), she will not be able to register invoices, and her performance will fall. One potential way for her to restore work performance levels is to receive instrumental support from co-workers so that the invoices can get registered again (H2a).

Instrumental support encompasses goods and services that support the user and decrease the feeling of loss of control (Taylor 2007). Techno-exhaustion is reduced by receiving concrete assistance from a co-worker or the IT help desk, which might decrease feelings of loss of control (Hogan et al. 2002). From a rational point of view, it is efficient to manage the consequences of techno-stressors by providing instrumental support because many techno-stressors result from the nature of the IT usage or organizational norms that cannot be changed (Weiss 1983). For example, a user who is registering invoices while working with undependable IT that does not respond properly feels, as a result, exhausted. But, after receiving instrumental support, the user can manage the undependable IT (e.g., unfreeze her computer), which mitigates techno-exhaustion (H2b).

The perception of techno-stressors activates the behavioral inhibition system (BIS) (Morgan 2006; Sutton and Davidson 1997). The BIS is responsible for guiding behavior in response to threats and novel stimuli. This requires users with limited resources to execute behaviors leading to behavioral inhibition (Sutton and Davidson 1997). When instrumental support is provided by others during stressful situations, the physiological response is decreased as stress-responsive physiologic systems are suppressed (Heinrichs et al. 2003). There is evidence that perceiving support also reduces the physiological response, for instance lowering blood pressure (Uchino et al. 1996).

The present paper theorizes that when a user is physiologically aroused in response to an unreliable IT system and receives instrumental support, the provision of assistance and help from others will also influence the activity of the HPA axis and the ANS (H2c).

> *$H2_{InS}$: Users who receive instrumental support when experiencing unreliable IT (a) perform better, (b) perceive less techno-exhaustion, and (c) have lower physiological arousal than those who receive no instrumental support.*

3.3 The impact of emotional support on end-user performance, techno-exhaustion, and physiological arousal

Studies have shown that users who receive the desired amount of emotional support perform better because receiving support from others leads to higher task accuracy (Searle et al. 2001). Receiving emotional support also restores the self-esteem of the user (Hogan et al. 2002), which is a significant performance factor. For example, receiving emotional support from supervisors and co-workers is associated with higher self-rated performance (Kaufmann and Beehr 1986). In the invoice registration example, the user's performance decreases due to an unreliable IT system that does not respond properly. But, receiving emotional support may restore her self-esteem and influence her end-user performance. Therefore, the study hypothesizes that receiving warmth and nurturance from others leads to higher accuracy and end-user performance (H3a).

One result of being exposed to techno-stressors are emotional responses, such as the perception of exhaustion (Ayyagari et al. 2011). Users might be able to stay in a stressful situation when they feel valued and appreciated but develop exhaustion when there is no emotional support (Moore 2000). Receiving emotional support restores the self-esteem of the user and allows him to express his feelings better in response to the care and concern communicated by others (Hogan et al. 2002). The negative feeling of techno-exhaustion might be mitigated when self-esteem is restored or due to the emotional support in the form of caring and concern communicated by co-workers, which may decrease techno-exhaustion. The paper hypothesizes that if users receive emotional support from others, the level of techno-exhaustion is lower than the level of techno-exhaustion of users receiving no emotional support (H3b).

Several studies have shown that receiving emotional support has a positive influence on cardiovascular activity (Uchino et al. 1996). Receiving a nod of agreement or a smile from others may lead to less physiological activation during stressful situations (Christenfeld et al. 1997). Users who receive emotional support might experience the techno-stressor as less threatening and perceive that they have greater control of the situation than users who receive no emotional support (Kirschbaum et al. 1995). Positive emotional interactions might modulate the activity of the HPA axis and the ANS (Heinrichs et al. 2003). For example, in a situation where a user is physiologically aroused because of unreliable IT, she may receive emotional support to reduce the perception of stress associated with the unreliability and the resulting physiological arousal (H3c).

$H3_{EmS}$: Users who receive emotional support when experiencing unreliable IT (a) have higher end-user performance, (b) are less techno-exhausted, and (c) are less physiologically aroused than those who do not receive emotional support.

3.4 Controls

Several previous investigations consider individual differences regarding technostress (Ayyagari et al. 2011; Ragu-Nathan et al. 2008). Their results show that men perceive techno-stressors stronger than women and that the perception of techno-stressors decreases as age, education, and computer confidence increase (Ragu-Nathan et al. 2008). They also show that age has a significant favorable influence on psychological arousal. Riedl et al. (2013) demonstrate that men show a higher level of physiological arousal than women when encountering a computer freeze under time pressure. In addition, the literature on social support indicates that the effects on strain responses are subject to individual differences (Taylor 2011). To shed light on the different effects of instrumental and emotional support, the present paper controls the impact of individual differences (gender, age, IT experience, and IT self-efficacy) on the relationship between social support and end-user performance, techno-exhaustion, and physiological arousal.

The effect of social support might depend on *gender*, because women tend to derive satisfaction more from talking about feelings, problems, and people, whereas men tend to derive satisfaction from instrumental task accomplishment (Cohen and Wills 1985). Women tend to provide more emotional support and, in turn, receive more help (Kessler et al. 1985) and attach more importance to intimacy and self-disclosure in their friendships and are generally more empathetic, expressive, and insightful than men (Bell 1981; Taylor 2011). *Age* is understood as the differentiation between chronologically younger users compared to elderly users (Tams et al. 2018). Research suggests that elderly users have more information stored in their working memory than younger, such that elderly users might prefer instrumental support where younger users prefer emotional support.

IT experience is defined as the *"extent to which an individual has been using computers over his or her lifetime"* (Tams et al. 2018, p. 864). As users with high IT experience have more experience in how to use a computer, they might understand the instrumental support more easily and can apply the instruction more accurately than users with low IT experience. *IT self-efficacy* is defined as the perceptions about the abilities to use the IT to accomplish a specific task (Compeau and Higgins 1995; Thatcher and Perrewe 2002). The past literature indicates that social support and IT self-efficacy are negatively related, such that IT self-efficacy is low when support is high or vice versa (Compeau and Higgins 1995). Those who have a strong self-efficacy believe in their ability to mobilize cognitive resources and action plans needed to accomplish a task. Task demands are less struggling, and the threat and anxiety are less likely to elicit stress and will be weaker (Lazarus 1999).

Therefore, the paper controls for the direct and moderation effect of age, gender, IT experience, and self-efficacy on end-user performance, techno-exhaustion, and physiological arousal.

4 Methodology

In the laboratory experiment, participants completed tasks working with MS SharePoint. This situation was manipulated by techno-unreliability, representing the undependability of the SharePoint System. During this situation, three treatment groups received different support types (no support, instrumental support, and emotional support). To analyze the research model, subjective data using two surveys at the pre- and post-experimental stage and objective skin conductance (SC) data were captured during the experimental stage. In this section, the methodology of the experiment, including experimental design, manipulations, experimental procedure, and measurement, as well as data analysis, is presented.

4.1 Experimental design and sample

The experiment followed a bi-factorial, inter-subject design. The design considered the factors stressor (techno-stressor/non-stressor) and social support (no support/emotional support/instrumental support). Notably, the design would be expected to encompass six different treatment groups. However, in the non-stressor condition, the subjects did not receive any support, such that there is only one control group (A) that perceived no techno-stressor and received no support. Hence, the experiment contained the following four groups: non-stressor group A (perceive non-techno-stressor and receive no support), no support group B (perceive techno-stressor and no support), instrumental support group C (perceive techno-stressor and receive instrumental support), and emotional support group D (perceive techno-stressor and receive emotional support). The experimental design is illustrated in Fig. 2.

To recruit participants, the experiment was promoted in different lectures of our department and advertised on several Facebook groups of users living in the city where the experiment took place. To increase participation, every participant received a meal voucher from the local cafeteria. A total of 80 subjects participated in the experiment, which is a sufficient sample size compared with previous SC studies in IS research (Eckhardt et al. 2012; Minas et al. 2014; Riedl et al. 2013; Teubner et al. 2015). The final sample contained 73 subjects because some participants had to be excluded because of measurement problems and missing values. The average age of the participants was 28, and most of the subjects were between 19 and 24 years old. The sample was almost evenly divided between men (52.1%) and women (47.9%).

The majority of the sample were students (69.9%), and the rest were employees (20.5%), self-employed users (1.4%), and pensioners (1.4%); 6.9% provided no work status information. This dominance of students within the sample partly reduces the generality of the paper (see limitations for further discussion). Nevertheless, the previous literature indicates that the use of student samples is feasible (Compeau et al. 2012) and that no systematic differences between the behavior of students and non-students could be found (Fréchette and Schotter 2015; Kagel 2016; King and He 2006). This lack of student/no-student effect was also seen in the present study. The values of the variables of interest do not significantly differ between the students and the non-

		Social support		
		No support	Instrumental support	Emotional support
Stressor	Techno-stressor	**B. no support group** Perceive techno-stressor, receive no support	**C. instrumental support group** Perceive techno-stressor, receive instrumental support	**D. emotional support group** Perceive techno-stressor, receive emotional support
	Non-stressor	**A. non-stressor group** Perceive no techno-stressor, receive no support		

Fig. 2 Design of the experimental study (between-subjects design)

Table 3 Demographics of the total sample and the four treatment groups

Demographics			A. Non-stressor (perceive no techno-stressor, received no support)	B. No support (perceive techno-stressor, received no support)	C. Instrumental support (perceive techno-stressor, received instrumental support)	D. Emotional support (perceive techno-stressor, received emotional support)
N	73		20	17	18	18
Gender (%)	Men	52.1	52.9	55.0	44.4	55.6
	Women	47.9	47.1	45.0	55.6	44.4
Age (%)	< 19	4.2	0.0	10.0	5.6	0.0
	19–24	54.2	64.7	45.0	61.1	47.1
	25–34	25.0	17.6	30.0	16.7	35.3
	35–44	1.4	5.9	0.0	0.0	0.0
	45–54	4.2	0.0	5.0	5.6	5.8
	> 54	11.1	11.8	10.0	11.0	11.8

students participants (see Table 12 Appendix), whereas the results of the experiment cannot be transferred to a real business situation (see limitation for further discussion).

Participants were randomly assigned to one of the four treatment groups. Across the treatment groups, no significant difference regarding the control variables could be observed (Age $F(3, 69) = 0.071$, $p = 0.975$; Gender $F(3, 69) = 0.185$, $p = 0.907$; IT-experience $F(3, 69) = 1.051$, $p = 0.376$; IT-self efficacy $F(3, 69) = 1.069$, $p = 0.368$). Participation was voluntary, and the data collection was completed in one month. The demographics of the overall sample and the four groups are displayed in Table 3.

4.2 Manipulation: techno-stressor and social support

4.2.1 Techno-stressor: simulated techno-unreliability

To simulate an episodical technostress situation, the IT used was intentionally manipulated. In particular, whereas participants in the non-stressor group were not exposed to a techno-stressor, participants in the three techno-stressor groups [no support (B), instrumental support (C), and emotional support (D)] were manipulated by being subjected to techno-unreliability. Several studies have focused on acute techno-stressors such as IT malfunctions, computer freezes or techno-unreliability (Galluch et al. 2015; Riedl et al. 2012; Tams et al. 2014, 2018). We chose to investigate techno-unreliability, which among others, represents the undependability of IT (Fischer and Riedl 2015). Techno-unreliability has been seen as a significant techno-stressor and has the advantage that participants have experienced it at some point. Also, the techno-unreliability manipulation was more reliably replicable in the context of a laboratory experiment than other techno-stressors such as work–home conflict or role ambiguity. Because of these reasons, a one-minute computer freeze during which the computer was not dependable was simulated (input via mouse or keyboard was impossible). The objective was to replicate precisely the way a user perceives the behavior of a system during a lockup using a short script for the MS-based GNU GPL application AutoHotkey[4] and proprietary libraries to lock the mouse and keyboard to the hotkey configuration CTRL + ALT + L, which could be activated remotely. When the system was locked, any input is ignored other than the hotkey for unlocking, CTRL + ALT + U. To guarantee that the script was not disrupted the standard sequences such as CTRL-ALT-DEL (CAD) or the CTRL-SHIFT-ESC were also blocked, which would have stopped the script otherwise, by running the operating system in a "kiosk" mode. The computers were running on MS Windows XP and configured to be lockable by remote access.

4.2.2 Social support: emotional and instrumental support

To manipulate the effect of social support, subjects received instrumental or emotional support. The *instrumental support group* (C) was manipulated by receiving instrumental support from the facilitator, which also represents a well-established social support type (Taylor 2011). When the subjects asked for help, the facilitator explained that they should press CTRL + ALT + U to unfreeze the computer, so these participants were exposed to the techno-stressor for a shorter period.

Since receiving sympathy and understanding from someone or general support for emotional reasons is an established emotional support type (Taylor 2011), the *emotional support group* (D) was manipulated by receiving emotional support from the facilitator. When these participants asked for help, the facilitator talked with the subjects about their feelings, encouraged them, and gave them sympathy and understanding of the situation caused by the manipulation by always saying to every subject in that group *"just keep cool, this can happen when you use a PC. I know this situation myself. Just stay calm.*" The facilitator also shows nonverbal understanding by nodding to provide warmth and understanding. This was repeated if the participant asked again.

The *no support group* was not manipulated. When the subjects asked for help, the facilitator did not answer and signaled non-verbally that he or she would provide no help or support.

4.2.3 Manipulation check

The manipulation check assesses whether the treatment groups have been faithfully and successfully manipulated (Recker 2013). The check attempts to ensure that the participants have been manipulated as intended (Straub and Gefen 2004). To ensure that the subjects of the experiment were successfully manipulated by techno-unreliability, the appraisal of the technology-related stimuli was measured by the 'threat appraisal' scale based on Liang and Xue (2010) (see Appendix Table 13). The scale captures the evaluation of whether the subjects within the treatment group perceived the undependable computer as a threatening technology-related stimulus and hence as a techno-stressor. The 'threat appraisal' scale was used because techno-stressors are *"IS stress creators*

[4] (https://www.autohotkey.com/).

appraised by the individual as threatening" (Tarafdar et al. 2019a, p. 5). Hence, if the participants appraised the undependable computer as threatening, it can be concluded that the participants perceived it as a techno-stressor.

The mean value shows that participants whose computers were undependable felt threatened by the manipulation, as the values of the three treatment groups were all above the scale mean value of 2.5 (5-point Likert scale ranging from 1 strongly disagree to 5 strongly agree). Furthermore, subjects answered techno-unreliability questions based on Ayyagari et al. (2011). The mean values of the no support (B; Mean (M) = 3.26), instrumental support (C; M = 2.10), emotional support (D; M = 2.52) groups were higher than the values in the control group (A; M = 1.87). The results of a one-way ANOVA test indicated that the perception of the manipulation significantly differs between the techno-stressor group (A) and the no support group (B) [$F(1, 36) = 18.724$, $p = 0.000$]. Based on all results, it is concluded that all treatment groups were aware of the techno-stressor manipulation.

The manipulation of social support was evaluated using the questions about "social support for emotional reasons" to verify emotional support and "support for instrumental reasons" to verify instrumental support (Carver et al. 1989). Post hoc results of two ANOVAs considering social support for instrumental [$F(2, 50) = 12.611$, $p = 0.003$; $n_2 = 0.335$] and emotional reasons [$F(2, 50) = 10.206$, $p = 0.003$; $n_2 = 0.290$] show that the perception of the manipulation of support significantly differed between the no support (B) and the two treatment groups instrumental support (C) and emotional support (D). For instrumental support, there was a significant difference between the no support condition (B) and the instrumental support condition (C) [mean differences (MD) = − 1.62; SE = 0.323; p = 0.000] as well as between instrumental support condition (C) and emotional support condition (D) (MD = 0.810; SE = 0.323; p = 0.016). For emotional support, there is a significant difference between the no support condition (B) and the emotional support condition (D) (MD = − 1.416; SE = 0.352; p = 0.003) as well as between instrumental support condition (C) and emotional support condition (D) (MD = − 1.349; SE = 0.358; p = 0.003). These findings indicate that the treatment groups were aware of emotional support or instrumental support mechanisms.

4.2.4 Tasks and technology used

In the experiment, participants completed three different tasks on a single worksheet using MS SharePoint 2010. The enterprise content management (ECM) system MS SharePoint was used to simulate a real working environment. ECM systems are common and used in almost every organization (Laumer et al. 2013; vom Brocke et al. 2011), so participants were familiar with doing different tasks using such systems. Moreover, participants did not need to be experienced in using MS SharePoint to fulfill the tasks. The results of each task were noted under the task description on the worksheet. Three simple tasks were developed as shown in Table 4. All participants worked on the three tasks in the same sequence.

Table 4 Tasks and work steps

Task 1	What are the street name and the house number of the company Joe and Bloggs Ltd?
Work steps	For the first task, the subjects were requested to search for a street name and a house number of a particular company in the customer list managed by the system. In this case, the subjects had to navigate from the main window to the correct list of clients and find the desired company and the requested information
Task 2	What is the date of the order placed by the company Sample Ltd?
Work steps	The second task asked for the date of a specific order from a company that is also stored in a list within the system. Here, the subjects had to navigate to the correct list within MS SharePoint and search for the required company and date of order
Task 3	How many orders were placed by Miss Sabrina Sample in 2013?
Work steps	In the third task, the subjects had to navigate to the correct list, search for the specific customer and count the exact number of orders. In this step, participants had to find the right order and customer in a long list containing similar orders and clients, such as Sabrina Sample or Sabrina Sampel, to make this task more complicated

4.3 Experimental procedure

The experiment was divided into a pre-experimental, experimental, and post-experimental phase. Beforehand, a pilot test was conducted and the experimental procedure was improved based on the results (see Appendix, pilot test). For the experiment, a sample of subjects who had not participated in the pilot test was recruited. The three stages are described in the following.

In the *pre-experimental stage,* participants were assigned randomly to one of the treatment groups and seated at a desk in the laboratory. Subjects were isolated from each other and completed the experiment independently. The experiment was introduced to the subjects as a performance test of a new version of MS SharePoint to reduce the bias in the real study. The facilitator then presented the procedure and the task of the experiment and allowed participants to ask questions about the experiment. Before the experimental stage began, the subjects were fitted with the SC equipment and filled out the first paper-based survey.

In the *experimental stage,* the participants moved to a computer workplace where they logged into MS SharePoint with a username and associated password provided. Subjects had to work on three different tasks described on three different cards lying on the desk in front of them. The order of the task was given such that the subjects had to finish one task before continuing with the next one. For each task, the participants had to find information within MS SharePoint (see section *Task and technology used*). If the subjects revealed an answer, they wrote it on the card below the task description and continued with the next task. However, if the subjects finished one task and continued with the next one, they were not allowed to go back to the previous task and change their answers. In all conditions, there was no time limit for each task such that the participants could take as long as they needed to complete each task. A time limit for each task would have posed an additional stressor within the experimental design and would have distorted the results of the experiment.

All subjects worked on tasks one and two under the same conditions, which were then adjusted for the third task for each group. The non-stressor group (A) completed task two and was able to continue with tasks three without any manipulation. These subjects completed task three and moved to the post-experimental stage.

The techno-stressor group (B) completed the first two tasks as all other subjects and was then manipulated in the way that the computer was undependable, i.e., the computer froze for one minute. The facilitator manually initiated the manipulation. This manipulation began once the participants had completed the second task by starting the techno-unreliability via remote access (see section *Techno-stressor: Simulated techno-unreliability*). During that time, subjects were not able to provide input via the keyboard or the mouse. The subjects in this group were not manipulated again and received no emotional or instrumental support from the facilitator. Participants had to wait one minute until the techno-unreliability ended before they could continue to work on the last task. After finishing task three, they moved to the post-experimental stage.

The instrumental support group (C) also completed the first two tasks before the manipulation was applied. The facilitator remotely initiated the techno-unreliability such that subjects within this group were not able to provide input via the keyboard or the mouse. However, during the situation, this group was again manipulated when the facilitator provided instrumental support. The second manipulation took place after the subjects asked the facilitator for help. The facilitator told the subject what to do to solve the problem with the frozen computer (see section *Social support: Emotional and instrumental support*). This type of support enabled the participants to solve the problem caused by the techno-stressor and continue to work on the last task after unfreezing the computer and, hence, move to the post-experimental stage.

The emotional support group (D) was also manipulated by techno-unreliability after finishing task two (see section *techno-stressor: Simulated techno-unreliability*). During this situation, no input from the keyboard or mouse was possible. However, this group was manipulated again when the facilitator provided emotional support in the form of sympathy and understanding after the subject asked the facilitator for support. The facilitator communicated with the subjects and showed them warmth and understanding of the situation (see section *Social support: Emotional and instrumental support*). This type of support did not enable the subjects to solve the problem caused by the techno-stressor, and the techno-stressor continued for one minute before participants were able to continue to work on the third task and hence move to the post-experimental stage.

Finally, after approximately ten minutes, the *post-experimental stage* started, the subjects left the computer workplace and were seated at a normal desk, where they filled out the second paper-based survey. This survey contained measurement items to confirm that the manipulations were experienced as well as captured dependent variables such as techno-exhaustion. The experimental procedure for each group is illustrated in Fig. 3.

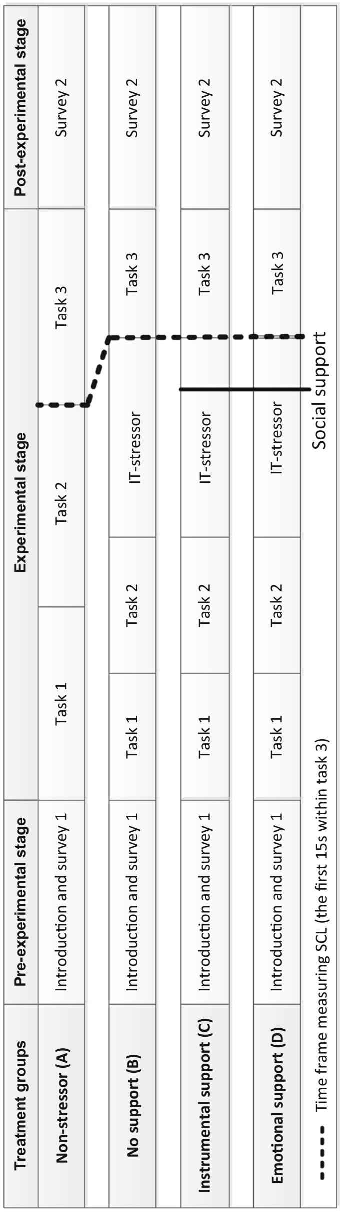


Fig. 3 Experimental procedure for each treatment group and point of analysis

4.4 Measurement

During the experiment, data in the pre- and post-experimental stages as well as during the experimental phases, were captured.

The first survey, which was conducted in the pre-experimental stage, collected data on demographics, including age, gender, education status, IT experience (Potosky and Bobko 1998), and IT self-efficacy (Marakas et al. 2007). The second survey, which was conducted in the post-experimental stage, measured perceived threat appraisal (Liang and Xue 2010), support for emotional and instrumental reasons (Carver et al. 1989), techno-unreliability (Ayyagari et al. 2011) and techno-exhaustion (Ayyagari et al. 2011). All measurement items are presented in the Appendix Table 13. All constructs were measured on a 5-point Likert scale (strongly disagree to strongly agree).

During the complete experiment, skin conductance (SC) was measured as evidence of physiological arousal. An exosomatic SC method was used, which applies direct current to the skin. Two electrodes were installed on the palmar surface of the participants' non-dominant hand to measure the low-level voltage between these electrodes. Participants' SC values were measured once per second using a MentalBioScreen K3 device, which recorded conductance in microsiemens (μS).

According to Marcolin et al. (2000), is it more appropriate to use a hands-on test to measure end-user performance instead of a self-assessment method, so end-user performance was measured objectively by recording the time needed to process task three (Gattiker and Goodhue 2005).

4.5 Data analysis

SC is divided into a tonic and a phasic component (Boucsein 2012). The tonic component is *"the absolute level of […] conductance at a given moment in the absence of a measurable phasic response"* (Dawson et al. 2007, p. 210). In other words, tonic values represent SC over a longer period of time and are referred to as skin conductance level (SCL). The phasic component takes the increases in conductance into consideration, which occurs in the tonic phase typically triggered by different external or internal stimuli. Increases in conductance are labeled as skin conductance responses (SCR; Boucsein 2012). In line with literature focusing on recovering from physiological strain (Lazarus 1966; Lazarus and Opton 1966), the paper concentrates on the tonic component of SC.

SC was decomposed into its tonic and phasic components. Furthermore, a specific time point for the data analyses was defined, which did not contain any phasic response that might arise from the perception of the techno-stressor. Also, a moment in which all treatment groups worked under the same conditions was identified. As a result, the first 15 s within task three were defined as the time of analysis, when all participants worked under the same conditions, regardless of whether they had experienced a techno-stressor or received social support. A dotted line representing this data point in the experimental procedure is illustrated in Fig. 3.

SCL data cannot be analyzed instantly because of the differences between the subjects. Lykken and Venables (1971) point out that the SCL of a relaxed subject could be twice as high as the maximum conductance of another subject, which is highly stimulated. To account for this variance, each value is set to the individual range from maximum to minimum SCL for each subject, which occurred during the whole experiment. This enabled us to adjust SCL data using an equation of correction for individual differences in range (see Lykken and Venables 1971, p. 667).

End-user performance was measured by tracking completion times for task three, which all treatment groups completed after the manipulation, i.e., working under the same conditions as the control group. Since all manipulations ended before task three, the time in which users were not able to use the system is not part of the end-user performance (Gattiker and Goodhue 2005).

To analyze the effect of the control variables, ordinal measured variables were transformed into a binary variable. This process is called centering and encompasses the "transforming a variable into deviations around a fixed point. This fixed point can be any value that is chosen [...]." (Field 2018, p. 782) It exists several approaches for centering a variable such as mean or median centering (Paccagnella 2006). Therefore, IT-experience and IT self-efficacy are mean-centered as it is the most used centering approach (Paccagnella 2006). In detail, high values are coded as one and summarize all the values equal or above the mean value of the construct [e.g., IT-experience ($M = 3.28$) and IT self-efficacy ($M = 4.00$)]. Low values are coded as zero and summarize all values lower than the mean value of the construct. As gender was already measured in a binary manner, women are coded as 0 and men as 1. Age has been split into young and old subjects. In line with past technostress literature (Maier et al. 2011, 2015a) young users are all subjects who are younger or equal than 49 years, and elderly users are all subjects older or equal than 50 years. To aid in comparing the results with the past literature, the paper adopted these thresholds.

5 Research results

This section first reports on tests whether the research model was reliable and valid. Then the research results are presented, including the effects of IT unreliability on end-user performance, techno-exhaustion, and physiological arousal, the direct influence of instrumental and emotional support on end-user performance, techno-exhaustion, and physiological arousal, and the results of a post hoc test to identify group differences in instrumental support and emotional support.

5.1 Reliability and validity analysis

To provide a valid and reliable measurement model for testing the hypotheses, the measurement constructs were first assessed. As all constructs were measured with reflective indicators, the measurement model was validated by focusing on content validity, indicator reliability, construct reliability, and discriminant validity (Bagozzi 1979).

Content validity: To ensure content validity for the perceptive measured variables, only items used in prior research were used, and each item discussed within the project

Table 5 Construct measucoloring is not corectres

Construct	Mean	Standard deviation	Item loading	Cronbach's alpha	AVE	CR	Number of items
Age	28.43	12.03	NA	NA	NA	NA	1
End-user performance	147.19	79.79	NA	NA	NA	NA	1
Gender	0.52	0.50	NA	NA	NA	NA	1
IT-Experience	3.28	1.19	0.842–0.938	0.93	0.82	0.96	5
IT self-efficacy	4.00	0.98	0.800–0.897	0.84	0.68	0.90	4
Physiological arousal	0.50	0.166	NA	NA	NA	NA	1
Support for emotional reasons	2.14	0.91	0.866–0.866	0.70	0.75	0.86	2
Support for instrumental reasons	4.08	1.15	0.735–0.929	0.76	0.61	0.86	3
Techno-exhaustion	1.29	0.41	0.707–0.861	0.77	0.63	0.87	4
Techno-unreliability	2.42	1.08	0.815–0.914	0.83	0.77	0.91	3
Threat appraisal	3.03	1.22	0.852–0.953	0.89	0.82	0.93	3

NA not applicable because of single-item construct

team. The question was slightly adjusted to fit the experimental setting. For example, the item *"I feel drained from activities that require me to use ICTs"* was changed so that it referred to the experiment and hence worded as: *"I feel drained because of the IT usage during the experiment."* All items used are presented in Appendix Table 13.

Indicator reliability: This reflects the rate of the variance of an indicator that comes from the latent variables. To ensure that 50 percent or more of the variance is explained by the indicators, each value should be at least 0.707 (Carmines and Zeller 2008). All other items were removed from the model. Table 5 shows that this condition was fulfilled.

Construct reliability: To determine the construct quality, composite reliability has been used, which should be at least 0.7, and average variance extracted (AVE), which should be at least 0.5 (Fornell and Larcker 1981). Also, Cronbach's Alpha should be at least 0.7. As shown in Table 5, all criteria were fulfilled.

Discriminant validity: This reflects the extent to which items differ from one another (Campell and Fiske 1959). The square root of AVE should be greater than the corresponding construct correlations (Fornell and Larcker 1981). Table 6 shows that the square roots of the values were greater than the corresponding correlations between the constructs.

Table 6 Inter-construct correlation

Construct	1	2	3	4	5	6	7
1. Age	NA						
2. Gender	− 0.019	NA					
3. IT experience	− 0.184	0.506	0.904				
4. IT self-efficacy	− 0.282	0.533	0.853	0.827			
5. Techno-exhaustion	− 0.082	− 0.046	− 0.219	− 0.282	0.793		
6. End-user performance	0.014	− 0.048	− 0.049	− 0.126	0.009	NA	
7. Physiological arousal	0.092	0.191	− 0.001	− 0.124	− 0.011	0.053	NA

Square root of AVE is listed on the diagonal of bivariate correlations; *NA* not applicable because of single-item construct

Table 7 Mean comparison between the social support conditions

Treatment groups	N	Dependent variables					
		End-user performance		Techno-exhaustion		Physiological arousal	
		Mean	SD	Mean	SD	Mean	SD
Non-stressor (A)	20	111.60	83.145	1.25	0.429	0.47	0.168
No support (B)	17	184.11	91.154	1.51	0.441	0.57	0.135
Instrumental support (C)	18	128.52	60.451	1.20	0.377	0.43	0.159
Emotional support (D)	18	167.44	60.858	1.18	0.319	0.53	0.177

End-user performance in seconds (high value = bad performance, low value = good performance); Techno-exhaustion measured on 5-point Likert scale (1 = not exhausted – 5 = exhausted); Physiological arousal measured in microsiemens μS (high value = high arousal – low value = low arousal)

5.2 The influences of techno-stressors on end-user performance, techno-exhaustion, and physiological arousal

The research model theorizes that techno-stressors reduce end-user performance and increase techno-exhaustion and physiological arousal (H1a-c). Mean comparison of the non-stressor (A) and the no support condition (B) shows that for end-user performance, the average time needed is shorter for the non-stressor group (A) compared to the no support condition (B). This reveals that subjects in the non-stressor condition (A) performed better than the subjects in the no support condition (B). A comparison of mean techno-exhaustion levels indicates that subjects in the non-stressor condition (A) are less techno-exhausted than the ones in the no support condition (B). Concerning physiological arousal, the findings show that subjects in the non-stressor condition (A) are less aroused than subjects in the no support condition (B), as demonstrated in Table 7.

Table 8 summarizes the results of three ANOVAs, which determined whether or not there were significant differences in end-user performance, techno-exhaustion, or physiological arousal levels. First, the differences between the two conditions non-

Table 8 ANOVAs and pairwise comparisons

ANOVA results Pairwise comparisons		Dependent variables								
		End-user performance			Techno-exhaustion			Physiological arousal		
		$F(3, 69) = 3.687$, $p = 0.016$**; $n_2 = 0.138$			$F(3, 69) = 2.701$, $p = 0.052$*; $n_2 = 0.105$			$F(3, 69) = 2.520$, $p = 0.065$*; $n_2 = 0.099$		
		End-user performance			Techno-exhaustion			Physiological arousal		
Group (i)	Group (j)	MD	SD	p	MD	SD	p	MD	SD	p
Non-stressor (A)	No support (B)	−72.51	24.55	0.004**	−0.26	0.13	0.044**	−0.11	0.05	0.044**
	Instrumental support (C)	−16.93	24.93	0.499^{NS}	0.04	0.13	0.737^{NS}	0.03	0.05	0.618^{NS}
	Emotional support (D)	−55.85	24.55	0.004**	0.07	0.19	0.591^{NS}	−0.06	0.05	0.247^{NS}
No support (B)	Instrumental support (C)	55.58	25.56	0.033**	0.30	0.13	0.024**	0.13	0.05	0.016**
	Emotional support (D)	16.67	25.19	0.510^{NS}	0.33	0.13	0.014**	0.04	0.05	0.390^{NS}
Instrumental support (C)	Emotional support (D)	−38.92	25.56	0.132^{NS}	0.03	0.13	0.851^{NS}	−0.09	0.05	0.112^{NS}

Social support is the independent variable; $p<0.01$***; $p<0.05$**; $p<0.1$*; $p>0.1^{NS}$; *MD* mean difference, *SD* standard deviation stressor (A) and no support (B) were analyzed. In the case of end-user performance, the results showed significant differences between these two conditions ($p = 0.004$; H1a = supported). Also, a significant difference between non-stressor (A) and no support (B) for techno-exhaustion ($p = 0.044$; H1b = supported) was found. The last comparison focused on physiological arousal. The findings showed that physiological arousal significantly differs between the two conditions ($p = 0.044$; H1c = supported).

5.3 The influence of social support on end-user performance, techno-exhaustion, and physiological arousal

The research model distinguished between instrumental support and emotional support and claims that both increase end-user performance and alleviate techno-exhaustion and physiological arousal. The three treatment groups no support (B), instrumental support (C), and emotional support (D) were compared. Our data on end-user performance indicate that subjects in the instrumental support and emotional support conditions performed better than subjects in the no support condition (B). A comparison of the instrumental support (C) and emotional support (D) condition showed that the subjects in the instrumental support condition (C) performed better than those in the emotional support condition (D). Concerning techno-exhaustion, the mean values of the instrumental support (C) and emotional support conditions (D) were lower than those in the no support condition (B). A comparison between instrumental support (C) and emotional support (D) showed that users in the emotional support condition (D) are less exhausted than those in the instrumental support condition (C). Turning to physiological arousal, our data demonstrated that subjects in the instrumental support (C) and emotional support conditions (D) were less physiologically aroused than those in the no support condition (B), and subjects in the instrumental support condition (C) were less physiologically aroused than those in the emotional support condition (D). Our results are presented in Table 7.

To statistically analyze the influence of instrumental and emotional support on end-user performance, techno-exhaustion, and physiological arousal, three different ANOVAs were conducted.

First, end-user performance in the no support (B), instrumental support (C), and emotional support condition (D) was compared. Our findings showed a significant effect [$F(3, 69) = 3.687$, $p = 0.016$; $n_2 = 0.138$]. Pairwise comparisons indicated that the mean score for the instrumental support condition (C) was significantly different from the mean value of the no support condition (B; H2a = supported). However, the emotional support condition (D) did not significantly differ from the no support condition (B; H3a = not supported).

Second, the influence of social support on techno-exhaustion was analyzed. A significant effect was observable between the four conditions [$F(3, 69) = 2.701$, $p = 0.052$; $n_2 = 0.105$]. A subsequent pairwise comparison showed that the mean score between the no support (B) and the instrumental support (C) as well as the emotional support condition (D) differed significantly (H2b and H3b = supported).

Third, the impact of social support on physiological arousal was analyzed. The results showed a significant effect [$F(3, 69) = 2.520$, $p = 0.065$; $n_2 = 0.099$]. In the

Table 9 Influences of the control variables on end-user performance, techno-exhaustion, and physiological arousal

Control variable	End-user performance			Techno-exhaustion			Physiological arousal		
	Df	MSE	F	Df	MSE	F	Df	MSE	F
Gender	1,71	1034.509	0.161^{NS}	1,71	0.025	0.150^{NS}	1,71	0.072	2.690^{NS}
Age	1,70	3642.907	0.563^{NS}	1,70	0.019	0.668^{NS}	1,70	0.097	0.452^{NS}
IT-experience	1,71	3453.548	0.540^{NS}	1,71	0.271	1.627^{NS}	1,71	0.000	0.005^{NS}
IT-self efficacy	1,71	2377.220	0.371^{NS}	1,71	0.476	2.914*	1,71	0.631	6.316**

MSE mean square of the error; $p<0.01$***; $p<0.05$**; $p<0.1$*; $p>=0.1^{NS}$

post hoc analysis, the mean score between no support (B) and instrumental support (C) was significant (H2c = supported), whereas no significant differences were observable between the no support (B) and emotional support (D) condition (H3c = not supported). Table 8 summarizes the results of all the ANOVAs.

5.4 Post hoc testing: the direct effect of controls on end-user performance, techno-exhaustion, and physiological arousal

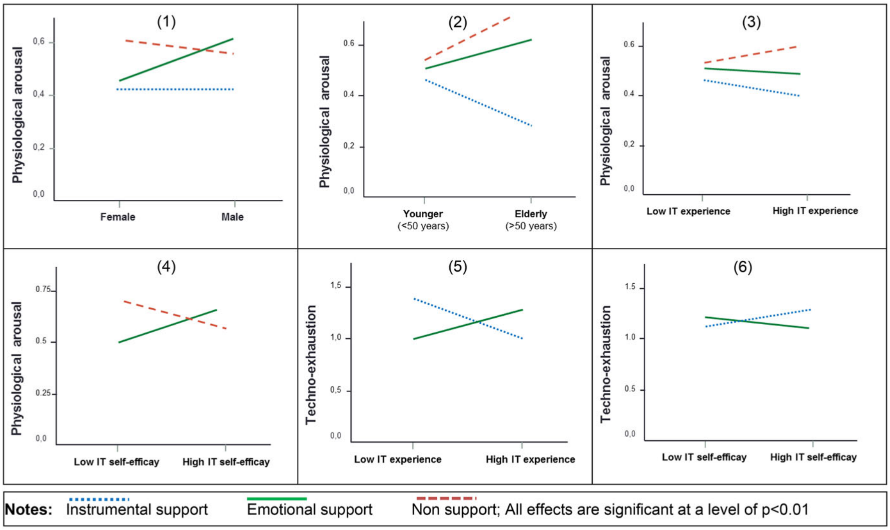
To test whether the control variables had a direct effect on end-user performance, techno-exhaustion, and physiological arousal, several ANOVAs were conducted, each for one dependent and control variable. The results of all control variables are reported in Table 9 and indicate that only IT self-efficacy influenced techno-exhaustion and physiological arousal. All other influences were insignificant.

5.5 Post hoc testing: The moderation effect of individual differences on the relation between social support and strain responses

As individual differences might influence the effect of support as explained above (see Sect. 3.4), whether any of these personal factors (gender, age, IT-experience, IT self-efficacy) moderate the effect of instrumental and emotional support on end-user performance, techno-exhaustion, or physiological arousal was tested.

Because the moderator variables and the independent variables were discrete, the paper followed a multisampling approach (Rigdon et al. 1998). The group comparison approach developed by Chin (2000) was adopted to analyze the moderating effect of the control variables on the relation between social support and end-user performance, techno-exhaustion, and physiological arousal. According to the group comparison approach, the direct effect of the exogenous variable on the endogenous variables is estimated separately for each group of interest (Henseler and Fassott 2010). The moderating effect was then interpreted as the differences in the model parameters between the different data groups and calculated by the formula developed by Chin (2000). The t-value and significance level are reported based on the group comparison

Table 10 Significant moderation of individual differences between social support and strain



method described above, as well as the mean differences between instrumental support and emotional support for each moderation condition.

The effect of all these personal factors (gender, age, IT-experience, IT self-efficacy) on the relation between support (instrumental and emotional) and the consequences (end-user performance, techno-exhaustion, physiological arousal) were investigated. All results are shown in Appendix Table 14. Six significant effects have been found, which are described below and visualized in Table 10. For the non-significant effects, see Appendix Table 14.

The results demonstrate especially that individual differences moderate the effect of social support on physiological arousal. The moderation analysis reveals that regarding *gender,* men receiving instrumental support experience less physiological arousal than men receiving emotional support. Men who receive emotional support are more physiologically aroused than men who receive no social support. Women show a significantly lower physiological arousal level in the emotional support condition compared to the no support condition (see Table 10, (1)). Concerning *age*, the results show that physiological arousal is lower for elderly users (≥ 50 years) who receive instrumental support compared to emotional support. Instrumental support and emotional support have almost the same effect for young users (<50 years; see Table 10, (2)). For *IT experience*, results indicate that users with low IT experience who receive instrumental support have a similar physiological arousal level as users who receive emotional support or no support. In contrast, users with high IT experience who receive instrumental support have a lowe physiological arousal level as users who receive emotional or no support (see Table 10, (3)). Users with high *IT self-efficacy* who receive emotional support are more physiologically aroused than users who receive no social support. Users with low IT self-efficacy who receive emotional support show a lower physiological arousal level than users receiving no social support (see Table 10, (4)).

For the effect of social support on techno-exhaustion, the results show that techno-exhaustion is lower for highly experienced users who receive instrumental support. On the contrary, users with less experience show lower techno-exhaustion when they receive emotional support (see Table 10, (5)). Users with high IT self-efficacy who receive emotional support are less techno-exhausted than users who receive instrumental support. On the contrary, users with low IT self-efficacy who receive instrumental support are less techno-exhausted than users who receive emotional support (see Table 10, (6)).

Taken together, the paper indicates that the effect of social support, either instrumental or emotional support, depends on individual differences of the users. Regarding gender, the findings align well with previous research results (Cohen and Wills 1985). Our results indicate that men should receive instrumental rather than emotional support to reduce physiological arousal. In addition, previous literature demonstrates that technostress mitigation does not always have a decreasing effect on technostress. For example Pirkkalainen et al. (2017), show that venting and distancing from IT are associated with increased strain. The present paper indicates that similar effects are shown by the influences of social support on strain responses. However, the results indicate that the individual difference of the users might explain these unexpected increasing effects of social support on strain responses. For example, users with high self-efficacy who receive emotional support are more physiological aroused than users who receive no social support. Users with high self-efficacy might instead need instrumental support to inhibit technostress. Hence, users need the appropriate technostress mitigation to reduce the effect of technostress. An arbitrary provision of technostress mitigation might result in worse strain responses.

6 Discussion and contribution

From a practical perspective, as the investments in support services in firms to provide help for employees perceiving technostress are high (Statista 2019), and technostress itself is still on the rise. Among others, literature has shown that IS usage can create technostress (e.g., Maier et al. 2015b; Tarafdar et al. 2015a; Tarafdar et al. 2019a) and emphasized the relevance of studying how to reduce the consequences of techno-stressors (Tarafdar et al. 2019a). From psychology research, we have so far known that one dominant behavior of users in stressful situations is to seek social support from others (Carver et al. 1989; Lazarus and Folkman 1984). So based on the practical relevance, it is relevant to see how different types of support reduce perceptions of technostress.

This paper uses an experiment to gather subjective (questionnaires) and objective (task performance and skin conductance measurements) data to investigate the effect of instrumental and emotional support on end-user performance, techno-exhaustion, and physiological arousal. Statistical results show that, indeed, techno-unreliability leads to reduced end-user performance, increased techno-exhaustion, and physiological arousal. Also, the findings reveal that instrumental support and emotional support affect these three strain responses in differing ways. Instrumental support directly affects end-user performance, techno-exhaustion, and physiological arousal, whereas emotional support only influences techno-exhaustion. The analyses also reveal some surprising influences of control variables such as gender (e.g., men respond better to instrumental support) and computer self-efficacy (users with high computer self-efficacy might even suffer worse from technostress when they receive emotional support) that underscore the need for differentiated responses to technostress. The next section summarizes the theoretical and practical contributions.

6.1 Theoretical contributions

The paper offers some implications for theory. While there is a growing body of instructive research that considers technostress mitigation from an organizational (see Table 1) and an individual perspective (see Table 2), the technostress literature largely neglects in both perspective the mitigating effect of social support. Technostress literature, which takes the organizational perspective, looks at generic support structures and suggests a collection of several organizational mitigation mechanisms (called technostress inhibitors) beneath the provision of support (Fuglseth and Sørebø 2014; Ragu-Nathan et al. 2008; Tarafdar et al. 2010). Despite the importance of such organizational support structures, there remains a paucity of evidence on how emotional concern and instrumental aid from other people directly mitigate strain responses from an individual perspective. Hence, the present research substantially extends prior technostress research focusing support structures from an organizational perspective (Fuglseth and Sørebø 2014; Ragu-Nathan et al. 2008; Tarafdar et al. 2015b) by not only revealing that the existence of a competent and knowledgeable help desk within the organization reduces technostress but also empirically demonstrate that the individual receiving of support either emotionally or instrumentally mitigates technostress. In addition, this individual perspective on social support in the context of technostress shows what type of social support should be provided to the user to alleviate the consequences of an acute techno-stressor.

From an individual perspective, the paper extends previous technostress mitigation literature (see Table 2) by enlarging the scope of mitigation effects by looking at the reducing impact of social support on technostress. Moreover, as previous investigations mostly consider either subjective data (Pirkkalainen et al. 2019; Tarafdar et al. 2019b) or objective data (Galluch et al. 2015) the present paper extends past work by using subjective and objective data. Psychological exhaustion was subjectively measured, whereas end-user performance and physiological arousal were objectively determined by time and skin conductance measurements. Therefore, the paper was able to indicate how a technostress mitigation effect in terms of social support influences the behavioral, psychological, and physiological responses of techno-stressors.

In addition, these different effects of instrumental and emotional support from an individual perspective on end-user performance, techno-exhaustion, and physiological arousal contain further implications for the technostress literature regarding each strain response.

The influence of instrumental and emotional support on *end-user performance* is perhaps from an organizational behavior perspective, not surprising. Several investigations show in a general work context that social support increases the productivity of employees (e.g., Eisenberger et al. 1990; Shanock and Eisenberger 2006). However, in the context of technostress, the effect of social support has been neglected so far. As previous literature shows that antecedence and consequences of stress and technostress differ, the effect of social support might as well (e.g., Ayyagari et al. 2011), but also because the present paper concentrates on an individual perspective whereas organizational behavior literature takes an organizational perspective. In addition, context is important in IS research because it is important to understand the environment of an individual to understand person–situation interactions and to provide clear boundary conditions (Sarker 2016). Hence, the present paper contextualizes the effect of social support on the technostress context. Thereby, the present paper is one of the studies investigating the mitigating effect of social support and, in particular, of instrumental and emotional support on end-user performance in the context of technostress. The paper extends individual mitigation literature such as Pirkkalainen et al. (2019), who reveal a positive effect of positive reinterpretation on IT-enabled productivity by drawing on the effect of social support. In particular, this research extends the knowledge of how the different types of social support restore end-user performance that has been reduced by techno-unreliability. The paper reveals that solving is better than consolation. In other words, providing warmth and understanding to an individual suffering from a technostress event does not restore the performance of the user, whereas the provision of instrumental help does lead to better user performance. So, the effect of social support on end-user performance depends on the provision of the correct type of social support.

By focusing on influences of instrumental and emotional support *on techno-exhaustion*, the paper extends previous technostress literature focused on techno-exhaustion (Ayyagari et al. 2011; Maier et al. 2014, 2015b; Pirkkalainen et al. 2017) by demonstrating what type of social support reduces techno-exhaustion. In particular, it is shown that instrumental and emotional support significantly reduce techno-exhaustion. Warmth and understanding, as well as help, reduce the perception of tiredness and fatigue while struggling with unreliable IT.

Regarding the influence of instrumental and emotional support *on physiological arousal*, the present paper extends prior investigations focusing on physiological arousal (Galluch et al. 2015; Riedl et al. 2012, 2013; Riedl 2013) that only rarely consider technostress mitigation. Therefore, the present study contributes to technostress literature such as Riedl et al. (2012, 2013) by showing that the physiological arousal caused by an acute techno-stressor can be reduced mostly by providing instrumental support. Furthermore, the results extend the findings of Galluch et al. (2015), who show that method and resource control moderate the relationship between techno-stressors and physiological arousal by demonstrating that social support directly reduces physiological arousal.

Taken together, the results contribute to the literature by showing the importance and types of social support effects on technostress that, so far, are hidden in general mitigating mechanisms and too undifferentiated to offer concrete insights into effective technostress countermeasures. Also, the paper supports prior theoretical assumptions by showing that technostress mitigation reduces strain responses directly and not merely indirectly. Moreover, the analyses disclose for the first time how the types of social support mitigate each strain response—end-user performance, techno-exhaustion, and physiological arousal—independently.

6.2 Practical contributions

The implications of social support research for practice are substantial. As the consequences of techno-stressors are a significant cost burden for organizations, examining the extent to which social support could reduce these costs is highly relevant to practitioners (Tarafdar et al. 2015a).

This study shows that social support mitigates techno-exhaustion and physiological arousal and increases end-user performance. Specifically, it is shown that instrumental support is generally more effective than emotional support for increasing end-user performance and reducing psychological and physiological strain. Our findings indicate that organizations striving to increase end-user performance and alleviate technology-induced psychological and physiological strain should consider improving their help desk services and providing group support to ensure that the support provided is solution-oriented and avoid delays in solving the problem. Based on our results, managers should establish standardized processes that prescribe contacting technical support when an IT problem is experienced rather than asking for understanding and emotional support from colleagues first. Turning to colleagues for emotional support not only prevents them from focusing on their tasks, but the emotional support received is also less effective in improving performance levels than solution-oriented support in resolving the problem.

Also, the post hoc results show that the effect of social support on techno-exhaustion and physiological arousal is influenced by individual factors such as gender, age, IT experience, and IT self-efficacy. Organizations should thus be careful when providing instrumental or emotional support because the effect of providing social support depends on individual differences. For example, users with high IT self-efficacy who receive emotional support are more physiologically aroused (i.e. stressed) than users who receive no social support. Hence, organizations should ensure that the support provided by the help desk varies depending on personal factors such as gender, age, IT experience, or IT self-efficacy.

7 Limitations and future research

The present research is limited in several ways. First, our experimental design only considers one specific acute techno-stressor, techno-unreliability, which might lower the generalizability and transferability of the results to other techno-stressors such as chronic techno-stressors (e.g., work overload, work-home conflict) mostly investigated by prior literature (Ayyagari et al. 2011; Maier et al. 2015b; Tarafdar et al. 2010; see also Appendix Table 11). Second, our experimental design is limited in its ability to create a typical work environment, such as pressure, multitasking, and interruptions. This was necessary because the focus should be on one stimulus caused by the computer freeze. Future research might investigate the effect of different techno-stressors (e.g., work overload, work-home conflict) on strain responses.

Regarding social support, the present paper only considers instrumental and emotional support. It neglects other types of social support (e.g., companionship or information support) because prior research indicates that two main mitigating effects exist in terms of problem- and emotion-focused mitigation (Lazarus and Folkman 1984). Future research might consider the effect of other types of social support (e.g., companionship or information support). In addition, while previous literature demonstrates different types of mitigation (e.g., mitigation of the techno-stressor, moderation of the techno-stressor-strain relationship, direct effect on strain; Salo et al. 2017; Weinert et al. 2019), the present paper focuses only on the direct effect of social support on strain responses as literature on social support suggests a direct effect and hence the experimental design depicts only the direct effect. Future research, however, might also focus on the moderation effect and the effect on the techno-stressor. Regarding the individual differences, the paper considers only the main attributes previously considered in the literature. The results might differ depending on the variable centering approach. For example, the centering of age is subjected to some limitations as we split the sample into younger (<50 years) and old (≥50 years) participants following past literature (Maier et al. 2011, 2015a). The moderation effect of age might be different when other centering approaches are used or when age is split into more than two groups.

Also, the facilitator was present during the whole experiment to provide support to the subject. The presence of the facilitator during the experimental phase might have influenced the social support abilities or the SC of the subjects. In addition, the facilitator provided social support to the subjects, while the effects of support might also depend on the person who gives support. However, this was needed to provide a stable and controlled environment within the experiment. The consideration of different support givers would have distorted the results.

Moreover, the majority within our sample are students, which reduces the generality of the present results. Section 10.2 in the Appendix provides a detailed discussion about the use of the student sample based on Compeau et al. (2012). Generally, the sample is suitable to validate the research model. However, the reaction of employees regarding an unreliable computer might be different from the reaction of students within a laboratory experiment. This is also a problem of external validity of the experiment as we, for example, intentionally excluded business factors such as pressure to perform or significant sanctions about poor end-user performance. The experiment focuses intentionally on the cause-effect correlation between techno-unreliability and strain responses. Future research might extend the present research by conducting a field experiment that can capture such business factors.

Furthermore, the present paper focused on a specific technology and did not consider a diversity of technology uses. The effects of instrumental support and emotional support should also be investigated with other technologies, including mandatory and voluntary technologies, and the effects of social support when using these various types of technology should be compared. In addition, as strain reduces IS usage intention

(Maier et al. 2015b; Williams et al. 2009), future research might examine the effect of social support on this relationship.

Concerning the strain response measurement, only one objective measurement has been used in the experiment, so the results are biased by mono-operationalization (Dimoka et al. 2012). Our investigation does not consider the phenomenon of eustress such that the increasing effect of techno-stressors and the resulting U-shaped response of performance or arousal are not considered. As there is a disagreement in psychological literature about whether psychological and physiological strain influence each other (Hellhammer and Schubert 2012), the present research does not investigate the influences of these strain responses. Hence, future research should focus on the interplay between behavioral, psychological, and physiological strain in a situation while working with unreliable IT.

8 Conclusion

The present paper investigates social support in the context of technostress. In particular, the research examines how instrumental and emotional support reduces end-user performance, techno-exhaustion, and physiological arousal caused by techno-unreliability. Our results show that generally, social support significantly influences end-user performance, techno-exhaustion, and physiological arousal. In detail, the findings identify differences between instrumental support and emotional support, indicating that instrumental support is more efficient than emotional support in counteracting the three investigated strain responses. Moreover, a post hoc analysis sheds light on different effects of instrumental and emotional support on strain responses depending on individual factors.

9 Appendix

9.1 Overview of techno-stressors

See Table 11.

Table 11 Overview of techno-stressors and their effects

Authors (ordered by years)	Episodic vs. chronic technostress	Techno-stressors	Dependent variables
Tarafdar et al. (2007)	Chronic	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	Productivity, role stress (role conflict, role overload)

Table 11 continued

Authors (ordered by years)	Episodic vs. chronic technostress	Techno-stressors	Dependent variables
Ragu-Nathan et al. (2008)	Chronic	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	Job satisfaction, organizational commitment continuance commitment
Tarafdar et al. (2010)	Chronic	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	End-user satisfaction, end-user performance
Ayyagari et al. (2011)	Chronic	Work-home conflict, invasion of privacy, work overload, role ambiguity, job insecurity	Emotional exhaustion
Riedl et al. (2012)	Episodic	System breakdown	Physiological strain (cortisol)
Riedl et al. (2013)	Episodic	System breakdown	Physiological strain (skin conductance)
Tarafdar et al. (2015b)	Chronic	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	Sales performance, technology-enabled innovation
Fuglseth and Sørebø (2014)	Chronic	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	Satisfaction with IT use, intention to extend the use of IT
Maier et al. (2014)	Chronic	Social overload	SNS exhaustion, SNS satisfaction, SNS discontinuous usage intention
Maier et al. (2015b)	Chronic	SNS-stress creators[a] (complexity, uncertainty, invasion, disclosure, pattern, social overload) Switching stress creators[a] (transition costs, sunk costs, replacement overload)	SNS exhaustion, Switching exhaustion, Discontinuous usage intention, discontinuous usage behavior
(Galluch et al. 2015)	Episodic	Overload and conflict	Physiological and psychological strain

Table 11 continued

Authors (ordered by years)	Episodic vs. chronic technostress	Techno-stressors	Dependent variables
(Pirkkalainen et al. 2017)	Episodic	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	Techno-exhaustion
(Pirkkalainen et al. 2019)	Chronic	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity)	IT-enabled productivity
(Tarafdar et al. 2019b)	Chronic	SNS-stress creators[a] (complexity, uncertainty, invasion, disclosure, pattern, social overload)	SNS addiction
(Maier et al. 2019)	Chronic	Techno-stressors[a] (techno-overload, techno-invasion, techno-complexity, techno-insecurity, techno-uncertainty)	Job burnout and user performance

[a]Second-order construct

9.2 Discussion of the student sample and its generalizability

As most of the participants of the study are students, it was a question whether students and other employees respond differently. Table 12 summarizes the results of a t-test comparing the results of the students with the results of the employees. The findings show that besides age there are no significant differences between these two groups

Moreover, as the present paper was based mostly on student subjects, it is important to explain whether the sample is appropriate for the present investigation (Bitektine et al. 2017; Compeau et al. 2012). To discuss the appropriateness of the sample to justify the implications of the present manuscript, the paper follows the recommendation by Compeau et al. (2012).

The *first* recommendation by Compeau et al. (2012) is to clearly present the goal of the research regarding its generalization. The present paper aims to generalize the empirical results of the study to a more general population. Thereby, the paper follows a Type ET generalizability (Lee and Baskerville 2003), which aims to generalize the empirical results to theoretical statements where these theoretical statements can be generalizable beyond the sample or domain in which that data has been measured. For example, this can be an *"unsampled portion of the population or the parts of the organization where the field worker has neither conduct conducted interviews nor collected data in other ways"* (Lee and Baskerville 2003, p. 236). More precisely, the paper aims to generalize the effect of instrumental and emotional support on the three strain responses from the student sample to a non-student sample

The second recommendation suggests explicitly defining the population that has not been directly observed but for which the theoretical implication also applies (Compeau et al. 2012). The present sample contains mostly students who are on average 25 years old. Moreover, three out of ten are employed at a company. The sample is described in Table 3. Recent investigations found no systematic differences between the behavior of managers and students (Fréchette and Schotter 2015; Kagel 2016) and no differences between students and non-students in an IT usage context (King and He 2006). Hence, the population the paper aims to generalize to are adult IT users who usually work with an IS (e.g., sitting on a desk in front of a computer).

The *third* recommendation is clearly and precatively justify the use of students as participants (Compeau et al. 2012). As mentioned above, the previous literature shows no systematic differences between the behavior of non-students and students could be found (Fréchette and Schotter 2015; Kagel 2016; King and He 2006). Hence, the paper based on a student sample as the objective of the paper is to investigate the change within strain responses when different types of social support are provided. The participants must work on tasks from their supervisor and work with an ECM system representing a utilitarian IS (Laumer et al. 2013). The experimental tasks were also inspired by real situations where information about a customer is needed. Also, the manipulation of the experiment in terms of a system freeze is so general that each IS user has experienced such a situation

Table 12 Comparison between students and non-students

Construct	Students		Non-students		t-value
	Mean	Standard deviation	Mean	Standard deviation	
Age	24.8	8.5	37.3	14.6	**– 4.558*****
End-user performance	141.0	69.3	161.5	100.1	– 1.011^{NS}
Gender	0.55	0.50	0.45	0.510	0.734^{NS}
IT-Experience	3.38	1.19	3.02	1.19	1.134^{NS}
IT self-efficacy	4.13	0.92	3.69	1.05	1.808^{NS}
Physiological arousal	0.51	0.17	0.48	0.14	0.795^{NS}
Support for emotional reasons	1.68	0.83	1.97	1.07	– 1.081^{NS}
Support for instrumental reasons	4.14	1.02	3.91	1.42	0.657^{NS}
Techno-exhaustion	1.26	0.39	1.34	0.45	– 0.727^{NS}
Techno-unreliability	2.47	1.09	2.31	1.09	0.550^{NS}
Threat appraisal	2.97	1.13	3.17	1.45	– 0.525^{NS}

$p<0.001$***; $p<0.01$**; $p<0.05$*; $p>=0.05^{NS}$

The *fourth* recommendation is to discuss the limitations of the research sample in light of the goals of the research (Compeau et al. 2012). As mentioned above, the goals of the research are to investigate how instrumental and emotional support influences end-user performance, techno-exhaustion, and physiological arousal. The student sample is thereby limited by representing the entire population. As the sample contains mostly students, we neglect by the reflection of children and elderly people above 65 years. Also, the sample is limited by characteristics such as work and life experience, and on the other side, it might be limited by the academic degree such that most of the participants have an academic degree or will obtain one in the near future.

The *fifth* recommendation is to discuss whether the implications of the research are consistent with the goals of generalizability and the choice of the sample (Compeau et al. 2012). The paper shows some implications for theory in terms of the effect of social support on strain responses. We argue that the strain responses shown by the sample do not differ from other users which using an IS; for example, physiological arousal is a bodily reaction that happens unconscious and hence is not limited to students. Techno-exhaustion and end-user performance are also not influenced by an academic degree but rather have been influenced by individual factors that we controlled for within the research. Hence, we believe that the effect of social support on end-user performance, techno-exhaustion, and physiological arousal can be also generalized to IT users in general and not only to students.

9.3 Measurement items

See Table 13.

Table 13 Measurement items

Constructs	Items	References
IT-experience	I can explain…how e-mail works	Potosky and Bobko (1998) 5-point Likert (very bad to very good)
	I can explain…how an operating system works	
	I can explain…how a database works	
	I can explain…how a local area network works	
	I can explain…how a computer works	
IT self-efficacy	I have the ability to install new software applications on a computer	Marakas et al. (2007) 5-point Likert (very bad to very good)
	I have the ability to set up a new computer	

Table 13 continued

Constructs	Items	References
	I have the ability to remove information from a computer that I no longer need	
	I have the ability to use a computer to display or present information in a desired manner	
Techno-unreliability	The performance and functionalities of the IT during the experiment was dependable[a]	Ayyagari et al. (2011) 5-point Likert (strongly agree to strongly disagree)
	The capability of the IT during the experiment was reliable[a]	
	IT was free from software errors, quality problems, and technical failures[a]	
Threat appraisal	The computer freeze threatened the successful processing of the tasks	Liang and Xue (2010) 5-point Likert (strongly disagree to strongly agree)
	Problem caused by the computer freeze threatened the successful processing of the task	
	The successful processing of the tasks was uncertain because of the freezing	
Support for instrumental reasons	I asked the instructor for help with the frozen computer	Carver et al. (1989) 5-point Likert (strongly disagree to strongly agree)
	I got advice from the instructor about what to do about the frozen computer	
	I talked to the instructor, who was able to do something about the frozen computer	
Social support for emotional reasons	I discussed my feelings about the frozen computer with the instructor	Carver et al. (1989) 5-point Likert (strongly disagree to strongly agree)
	I got sympathy and understanding for the situation in which the computer froze from the instructor	

Table 13 continued

Constructs	Items	References
Techno-exhaustion	I feel drained because of the IT usage during the experiment I feel tired because of the IT usage during the experiment During the experiment, working with IT was a burden for me I feel burned out by working with the IT during the experiment	Ayyagari et al. (2011) 5-point Likert (strongly disagree to strongly agree)

All other items are objectively measured
[a]Items are reverse coded

9.4 Pilot test

A pilot test was conducted to identify the critical items of the manipulation to make sure that the tasks were understandable even for subjects who have not used the ECM system before and to clarify how the social support mechanisms could be provided properly. Furthermore, it was used to ensure that all measuring instruments could be installed in time and to test the whole experimental procedure. The pilot test was conducted using five subjects drawn from the same population as the subjects from the following experiment, and who had been interviewed subsequently. The manipulation time was increased from 30 s to 1 min, because some subjects sought help after only 25 s, so the manipulation was almost over before the participants started to cope. Additionally, three out of five subjects were not able to solve task four, so an easier task was developed. The whole worksheet with all the tasks was also substituted by single worksheets for each task so that the subjects were not able to see all the tasks at the beginning of the experiment and had to follow the correct order of the tasks. The behavior of the facilitator responding to EFC efforts was changed, so the facilitator offered general sympathy and understanding regarding the situation. In general, various responses and questions from the subjects led us to limit the behavior of the facilitator more strictly to ensure that all subjects were treated equally. Also, the point in time when the measurement items were attached was changed to avoid irritating the subjects during the experiment. The pre-test also showed that external factors should be controlled, so all cell phones were turned off, all windows were closed, and nobody was permitted to enter the room during the experiment.

9.5 Post hoc analyses

See Table 14.

Table 14 Interaction effects of inter-individual differences

			End-user performance			Techno-exhaustion			Physiological arousal		
			Instrumental support (C)		Emotional support (D)	Instrumental support (C)		Emotional support (D)	Instrumental support (C)		Emotional support (D)
			No support (B)	Emotional support (D)	No support (B)	No support (B)	Emotional support (D)	No support (B)	No support (B)	Emotional support (D)	No support (B)
Gender	MD (i-j)	Male	43.344	62.694	−19.350	0.331	0.024	0.306	0.126	0.166	−0.040
		Female	71.000	19.575	51.425	0.281	−0.0687	0.350	0.143	0.025	0.118
		T	0.001^{NS}	0.010^{NS}	0.008^{NS}	0.001^{NS}	0.599^{NS}	0.009^{NS}	0.500^{NS}	**2.460*****	**5.465*****
Age	MD (i–j)	Young	44.156	34.619	9.527	0.283	−0.002	0.286	0.091	0.055	0.036
		Elderly	145.500	79.667	65.833	0.500	−0.042	0.548	0.474	0.342	0.132
		T	0.002^{NS}	0.024^{NS}	0.013^{NS}	1.365^{NS}	1.501^{NS}	0.590^{NS}	**2.485*****	**5.774*****	0.732^{NS}
IT-experience	MD (i-j)	High	−89.111	−28.313	−60.799	−0.333	0.090	−0.424	−0.209	−0.132	−0.076
		Low	−20.583	−60.821	40.238	−0.288	−0.058	−0.230	−0.053	−0.038	−0.014
		T	0.005^{NS}	0.007^{NS}	0.013^{NS}	0.351	**1.841***	1.286^{NS}	**3.416*****	**4.164*****	0.712
IT self-efficacy	MD (i-j)	High	−19.1944	−60.607	41.4127	−0.270	0.157	−0.428	−0.074	−0.115	0.040
		Low	−111.177	−49.309	−61.868	−0.377	−0.100	−0.278	−0.228	−0.114	−0.114
		T	0.007^{NS}	0.008^{NS}	0.013^{NS}	0.802^{NS}	**2.968*****	0.488^{NS}	**2.685*****	1.198^{NS}	0.650^{NS}

End-user performance in seconds (high value = bad performance – low value = good performance); Techno-exhaustion measured on 5-point Likert scale (1 = not exhausted – 5 = exhausted); Physiological arousal measured in microsiemens µS (high value = high arousal – low value = low arousal); $p<0.01$***; $p<0.05$**; $p<0.1$*; $p>=0.1^{NS}$

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