Theorizing Technostress in Organizations: A Cybernetic Approach

Thomas Fischer[1], René Riedl[1,2]

[1] University of Applied Sciences Upper Austria, Steyr, Austria
{thomas.fischer,rene.riedl}@fh-steyr.at
[2] University of Linz, Linz, Austria

Abstract. We report the outcome of a research project which has the goal to develop a theoretical framework that makes it possible to gain an advanced understanding of employees' perceptions of technostress in organizations. We argue that such a framework is urgently needed, because empiricism has far outstripped theory-building in the field of technostress. In the course of analyzing theories of stress used in organizational research, we identified cybernetics as a potentially fruitful theoretical lens through which technostress in organizations can be studied. Specifically, we merged two major stress models based on cybernetics and integrated findings from previous technostress research into this unified framework. This new framework aims to advance the understanding of technostress in organizations.

Keywords: Computerstress, Coping, Cybernetics, Stress, Technostress

1 Introduction

The introduction of information and communication technologies (ICT) in work environments has led to multiple benefits for individual employees (e.g., the automation of tedious tasks) and organizations as a whole (e.g., reduced cycle times, cost savings, and innovations) [1]. However, in recent years it has also been acknowledged that stress is a ubiquitous phenomenon in the workplace throughout organizations worldwide despite the high degree of ICT use in many organizations [2]. Thus, it is questionable whether ICT really has the potential to effectively reduce work stress. Ironically, researchers have even started pointing to the significant potential of ICT to act as a new source of work stress. This form of stress is referred to as *technostress* [3–6], hereafter TS.

TS has been defined as "any negative impact on attitudes, thoughts, behaviors, or body physiology that is caused either directly or indirectly by technology" [7, p. 5]. In addition to this relatively abstract definition, more specific definitions have been developed. Riedl [3], for example, conceptualizes TS as a phenomenon that arises from "direct human interaction with ICT, as well as perceptions, emotions, and thoughts regarding the implementation of ICT in organizations and its pervasiveness in society in general" [3, p. 18].

12th International Conference on Wirtschaftsinformatik,
March 4-6 2015, Osnabrück, Germany

Fischer, T.; Riedl, R. (2015): Theorizing Technostress in Organizations: A Cybernetic Approach, in: Thomas. O.; Teuteberg, F. (Hrsg.): Proceedings der 12. Internationalen Tagung Wirtschaftsinformatik (WI 2015), Osnabrück, S. 1453-1467

Both academics and practitioners have become aware of the fact that they cannot ignore the "dark side" of ICT, especially TS [3]. A better theoretical understanding of the phenomenon is urgently needed, thereby supporting the development of effective organizational interventions and countermeasures. In the course of analyzing theories of stress used in organizational research, we identified *cybernetics* as a potentially fruitful theoretical lens through which TS in organizations can be studied. This theory concerns the functioning of self-regulating systems [8], and cybernetics is widely accepted as a theoretical framework for understanding human behavior [9]. Because we could not identify research in the TS field that applied cybernetics as a theoretical basis, the present paper aims to contribute to closing this significant research gap. Specifically, in this paper we discuss two major stress models based on cybernetics, and merge them into one theoretical framework. Moreover, we integrate findings from previous TS research into the theoretical framework, and also discuss the framework's application.

2 Technostress and Cybernetics

Previous research has revealed a number of insights into TS sources and creators (i.e., stressors such as computer breakdown) [10], [11] and negative consequences (i.e., strains, reflected in reactions such as elevations in stress hormones [12], elevated levels of mental strain [13], or reduced work productivity [11]). Research also examined variables that moderate stressors' impact on strain (e.g., gender [14]), along with possible interventions that may reduce perception of stressors or the emergence of negative consequences (i.e., coping, e.g., organizational break schedules [15]). From an Information Systems (IS) perspective, it has become clear that ICT can be seen as a double-edged sword, creating both individual and organizational benefits, but also detrimental effects. In other words, technology can be both, friend *and* foe [3, p. 18]. Hence, the importance of research into TS is indisputable and may even result in a new generation of stress-sensitive adaptive enterprise systems [16].

However, only a limited number of TS studies so far have focused on the organizational level of analysis (there is more of a focus on the individual level), and even fewer studies have been conducted in field settings; there is more of a focus on laboratory research (for a review, see [3]). Research on the individual level is crucial to understand stress, as the phenomenon ultimately occurs on this level being dependent on cognitive processes of the individual ("perception, emotions and thoughts"). Yet, it is essential to consider stress as a phenomenon arising from the *interplay* between the individual and his/her environment. Thus, in order to fully understand the nature and dimensionality of TS in an organizational context, measurement on an individual level is necessary; yet, it is not sufficient.

This understanding of stress (i.e., a phenomenon resulting neither solely from the individual nor the environment, but being a consequence of their interplay) forms the basis of most modern organizational stress theories, such as the transactional approach [17] or person-environment fit theory [18], and is the result of a long process of development in stress research. While early research into stress attributed stress to

processes occuring in the individual (predominantly biological processes, see [19]), later studies focused on stress sources outside of the individual, thus attributing the emergence of stress to environmental factors [20]. An irrevocable sign of the triumph of interplay-based theories in organizational stress research, however, is the existence of feedback loops in theoretical models [9]. A basic version of such a feedback loop is depicted in Figure 1 [21]. The feedback loop is one of the major characteristics of the cybernetic approach.

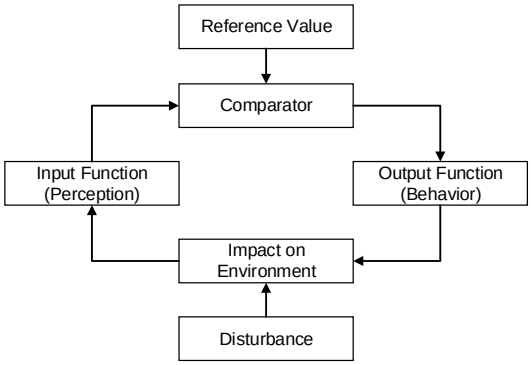

Figure 1. Feedback Loop, adapted from Carver and Scheier [21]

Based on input from the environment, an individual appraises the current state through perceptual processes ("Input Function"). Next, the current state is compared to a reference value (e.g., needs, goals, or desires), potentially revealing a discrepancy, which, in turn, activates behaviors with the goal of reducing or eliminating deviations from the reference value ("Output Function"). The principle that feedback controls behavior is known as the *negative feedback loop* [22] ("negative" because feedback reduces deviations from desired outcomes), and it forms the basis of self-regulating systems. Generally, the concept of negative feedback loops originated in cybernetics [8]. Originally developed to construct self-regulating mechanical systems, the principles of cybernetics, including the negative feedback loop, were later also used to better understand human behavior [8].

Importantly, an essential aspect of organizational stress (including TS) which can be captured by the negative feedback loop is its *time dimension*. Stress perceptions may change as a result of the implementation of coping mechanisms or other changes related to the interplay between the individual and the environment. Thus, in stress theories that consider the time dimension, such as those based on cybernetic principles [23], stress emerges from dynamic processes, driven by information processing (e.g., information about the environment) and feedback mechanisms, particularly feedback on the success of implemented coping behaviors (i.e., whether a specific behavior successfully reduced, or even eliminated, perceived stress). To sum up, organizational theories of stress based on cybernetic principles offer a fruitful approach to the study of TS, particularly due to the explicit consideration of

- the interplay between the person and the environment, and
- the negative feedback loop as an indicator of a time dimension.

3 Organizational Theories of Stress in Technostress Research

Complementing the original review of TS studies by Riedl [3], which considered peer-reviewed journal articles published between 1978 and 2012, we applied the same methodology to identify possible new studies that have been published in the meantime. This methodology involved a search via Google Scholar, based on the term "technostress" and a consideration of journal articles which had been cited at least 5 times; the search for articles stopped at the end of October 2014.

In total, we identified 17 studies with a focus on TS from an organizational perspective (e.g., questionnaire-based studies collecting data from individuals in the context of organizations, e.g., [5]), stretching back as far as the late 1970s [24]. Ten out of those 17 studies neither have an explicit theoretical foundation, nor do they have a theoretical basis that pertains to the organizational level [11–13], [15], [24–29]. Rather, these studies are of an empirical nature, typically reporting correlations between variables. However, 7 papers explicitly applied theories of organizational stress.

As shown in Table 1, four organizational theories of stress have been used in TS research so far. Importantly, while a number of papers published in non-IS journals (e.g., medicine, ergonomics, or psychology) do not explicitly apply organizational theories of stress (see the ten references in the previous paragraph), this is usually not the case for papers published in IS journals [4–6], [30]. Thus, current TS research in the IS field significantly builds on theories from organizational stress research.

With the exception of Karasek's Job Strain model (which has a focus on environmental factors, such as job characteristics), the Transactional Model, the Stress Cycle, and the Person-Environment Fit Theory share the understanding that stress results from an interplay of the individual and his/her environment [9]. Moreover, these three models consider feedback-directed behavior, and hence these models are dynamic in nature. For example, the Transactional Model conceptualizes processes of appraisal [31], and all three models comprise constructs related to coping, indicating that specific actions may change the situation, thereby creating new information, and hence prompting further loops in case of remaining discrepancies. Importantly, despite the fact that current theories of stress in TS research implicitly involve cybernetic features, cybernetics as an explicit theoretical lens offers additional insights into TS.

The cybernetic approach to organizational stress explicitly focuses on the subjective occurrence of stress by involving individual preferences or desires as *reference values* in the interplay between individual and environment [9], [22]. While theories such as the Transactional Model focus on environmental demands and how these can be satisfied by an individual's resources and abilities [31], cybernetics emphasizes the importance of individual differences in this context [9]. As an example, two individuals with the same abilities and perceiving exactly the same stressor (e.g., computer breakdown) might exhibit different levels of stress due to distinct desires (e.g., both individuals want to complete the task before leaving work, however, one wishes to leave work earlier). Thus, even in case of a phenomenon which is relatively universal in nature (i.e., computer breakdown), the extent of its stress-invoking potential is significantly affected by the importance given to computer functioning by an individual's set of desires in a specific situation.

Table 1. Organizational Theories of Stress used in TS Research

Organizational Theories of Stress	*Description*
Transactional Model of Stress and Coping *Referenced by:* [5], [6], [30]	Based on Lazarus' [17] understanding of stress being created by the interplay between an individual and the environment, this model posits that stress emerges when environmental demands tax an individual's resources. Thus, this theory focuses on the transaction between an individual and the environment. Through primary appraisal, an individual assesses possible detrimental effects, and through secondary appraisal the individual selects coping behaviors.
McGrath's Stress Cycle *Referenced by:* [32]	McGrath's stress cycle [33] (1st edition 1976) adopted the understanding of stress proposed by Lazarus and proposed a four-staged stress cycle: the objective situation, perception of the objective situation, selection of a response, and the individual's behavior. Additionally, McGrath identified six categories for possible sources of stress: task, role, behavior setting, physical environment, social environment, and person.
Person-Environment Fit Model *Referenced by:* [4]	The person-environment fit approach to stress [18] theorizes stress to be the result of a misfit between characteristics of the individual (abilities or needs) and the environment (demands or supplies). Misperception of the individual and/or the environmental side of this relationship is the major cause of stress.
Job Strain Model by Karasek *Referenced by:* [34], [35]	The Job Strain Model by Karasek [36] focuses on the influence of environmental characteristics, specifically job design, on the individual. It posits that high job demands in combination with low job decision latitude lead to job strain (i.e., negative effects of stress in the individual).

Other important characteristics of cybernetic models of stress related to coping can also shed light on previously unexplored theoretical mechanisms, thereby bringing fresh new insights into TS research [9], [37]. Ashby's *Law of Requisite Variety* [38] is one characteristic; this law specifies: If a system is to be stable, the number of states of its control mechanism (e.g., coping mechanisms) must be greater than or equal to the number of states in the system being controlled. This notion has later been advanced in the context of stress research by Cummings and Cooper [37]; they added that coping mechanisms need to match the complexity of a disturbance. For example, the stress caused by the crash of a software program which immediately starts to reboot could be sufficiently alleviated by a short break, while the complete crash of a desktop system without any signs of immediate improvement may require more complex measures (e.g., requesting technical support).

Also, Cummings and Cooper [37] in their research on cybernetics and organizational stress added the idea that coping may have cumulative effects, predominantly because different feedback loops are typically interrelated. These cumulative effects are mainly learning effects which will alter the choice of potential adjustment behav-

iors (e.g., an individual who has already experienced several computer breakdowns in the past and learned how to more effectively cope with such events).

Despite these valuable insights inherent in cybernetic approaches to stress, to the best of our knowledge, so far no TS study published in a peer-reviewed scientific journal has utilized a theoretical foundation that is explicitly based on cybernetics. In the following text, we therefore discuss two major cybernetic models of stress, namely the models proposed by Cummings and Cooper [22], [37] and Edwards [9], [23].

4 Cybernetic Models of Organizational Stress

We found that even though cybernetics has not been applied in TS research so far, studies based on cybernetics exist in related IS research domains, demonstrating the basic utility of the cybernetic approach in IS research. Liang and Xue [39], for example, used cybernetic principles in their investigation of technology threat avoidance. Frone and McFarlin [40], to state another example, used cybernetics principles to study the moderating effects of private self-consciousness (i.e., the degree to which individuals pay attention to their emotional experiences and bodily sensations) on occupational stress. However, a cybernetic theory explicitly created for the study of TS as an organizational phenomenon does not exist. However, two seminal models for research in the wider field of occupational stress do exist, and we base our TS framework on these two models: the "Cybernetic Framework for Studying Occupational Stress" by Cummings and Cooper [22], [37] and the "Cybernetic Theory of Stress, Coping and, Well-Being in Organizations" by Edwards [9], [23].

Both models have been applied in stress research (e.g., [40]), and have also been revised in order to increase their explanatory power [23], [37]. Additionally, Edwards [23] successfully replied to criticism (e.g., cybernetics is putatively not adequate for human behavior studies as cybernetics was originally concerned with the functioning of mechanical systems), substantiating the notion that cybernetics is a vital theory base in organizational stress research. Against this background, and considering that the original versions of the two models have been published in highly reputable academic journals, it is safe to assume that both models have been thoroughly discussed, criticized, and improved in the course of their evolution. In short, both models constitute high-quality academic research. This conclusion is substantiated by the fact that both models have received considerable attention in the scientific community so far (Google Scholar indicates 157 citations for the 1979 paper by Cummings and Cooper, and 372 citations for Edwards' 1992 paper; query on November 1, 2014).

The model by Edwards [23] is more specific than the model by Cummings and Cooper [37]. For example, while Edwards proposes a construct denoted as "desires," Cummings and Cooper define a similar construct which is more abstract in nature, namely "preferred state." While such subtle differences might appear as unimportant, this is not the case, as a preferred state might refer to goals, values, interests, needs, or expectations, and not only to desires; see a corresponding discussion in [9, pp. 249-250]. Thus, a model's level of abstraction cannot be ignored. Depending on the level of abstraction, theoretical constructs, which may appear similar at first glance, often

reflect different phenomena in the real world, a fact that has multiple consequences, such as those related to construct measurement. In addition, Edwards [23] explicitly cites moderators (e.g., importance and duration of discrepancy), while the model by Cummings and Cooper does not, which further demonstrates Edwards's model's higher degree of specificity. However, particularly with respect to coping, the model by Cummings and Cooper [37] offers richer details than the Edwards model, and hence we decided to integrate both models (with the Edwards model serving as the base model).

The possibility to integrate both models into one framework is based on the following facts: they have the same focus (i.e., organizational stress), they use a similar process perspective based on the negative feedback loop (see Table 2), and their constructs embedded in the theorizing process exhibit similarities (see Table 3). In the process of model integration, in the case of existence of similar constructs we always used the construct with the higher degree of specificity for our new framework. Moreover, based on the integrated model, we directly applied insights from previous TS research in order to add the TS component to the framework. Our new integrated theoretical framework of TS based on cybernetics is illustrated in Figure 2.

Table 2. Cybernetic Models of Organizational Stress

Cybernetic Framework for Studying Occupational Stress	*Cybernetic Theory of Stress, Coping and Well-Being in Organizations*
The model by Cummings and Cooper [22], [37] builds on the premise that living systems try to sustain some kind of steady state [41] with each variable involved having a specific range of stability [22]. Any force disturbing this steady state, threatening a variable to leave its range of stability, is referred to as *stress*, requiring an adjustment process. This process is basically designed in the form of a cycle (feedback loop), including four main stages: (1) detection of strain, (2) choice of adjustment processes, (3) implementation of adjustment processes, and (4) effects of adjustment processes on the stress or threat situation.	The model by Edwards [9], [23] is partly based on the model by Cummings and Cooper as it was developed after reviewing a total of six organizational theories of stress (including the Cummings and Cooper model). Specifically, this model is based on the assumption that a situation has to be appraised (perception) before it can be compared to preferred states or conditions (desires), revealing discrepancies (stress). The negative effects of these discrepancies on well-being (strain) initiate efforts to either reduce stress or improve well-being directly (coping).

Note: In this paper, we do not discuss the extension of Edwards' model to stress, coping, and well-being in multiple life domains, because our theorizing is focused on organizational settings. Yet, we acknowledge that the most complete picture of human stress perceptions, including effects on well-being and coping, can be drawn based on consideration of all life domains, including work and family, among many other areas. For details, please see Edwards [23, pp. 135-144].

Table 3. Comparison of Constructs

Cybernetic Framework for Studying Occupational Stress	*Cybernetic Theory of Stress, Coping and Well-Being in Organizations*
Actual State	Physical and Social Environment Personal Characteristics Cognitive Construction of Reality Social Information Processes
Perception of Actual State	Perception
Preferred State	Desires
Comparison of Preferred and Actual State	Discrepancy Importance Duration
-	Well-being
Variety of Adjustment Processes Choice of Adjustment Processes Implementation of Adjustment Processes Effects of Adjustment Processes Properties of Feedback	Coping

5 Cybernetic Framework for Technostress Research

Starting on the input side of the loop (Figure 2, left), the model by Edwards proposes that stress arises from a discrepancy between an individual's perception of the current state and a desired state. The perceptual side of this comparison is almost similar in both models, including the actual state and its appraisal by the individual (perception).

The actual state encompasses all elements of reality and the perceived state those elements that an individual is able to perceive. In addition to the fact that perceived state is affected by actual state (e.g., perceived frequency of computer breakdowns and the actual frequency), Edwards also showed that components of the actual state can alter an individual's perception (e.g., colleagues' comments on their perception of frequency of computer breakdowns in the organization), indicating that elements of the actual state are both the object of perception and at the same time exhibit influence on perception (see the curved arrow in Figure 2, left bottom corner).

With respect to actual state, our framework is based on five categories which may act as antecedents of TS perceptions (i.e., individual characteristics, job characteristics, technological environment, organizational environment, and social environment) [33], [42].

Individual characteristics whose impact on TS experiences has been demonstrated include objective characteristics of the individual such as age [5], [43], a user's skills and abilities such as computer literacy [28], and personality characteristics such as negative affectivity [4]. Furthermore, Edwards [23] indicates that an individual's cognitive construction of reality (i.e., active construction of subjective reality in absence of sufficient information) can be a characteristic that significantly influences

perceptions. *Job Characteristics* encompass elements related to the role of an individual in an organization and the tasks he/she has to fulfill. In the context of TS research these include, for example, the degree of job control [42] or the job content [12], [13]. Next, one of the most important categories in TS research, distinguishing it from more general research into occupational stress, is the focus on the *technological environment*. In this context, Ayyagari et al. [4] demonstrated that characteristics of technology (e.g., pace of change, anonymity, and reliability) are related to potential stressors. Riedl et al. [10], [14], to state another example, found that reliability (i.e., stable vs. crashed computer) can directly lead to biological stress in users. Importantly, two decades prior to these findings, Hudiburg [44] already developed a comprehensive list of computer hassles, all of which may constitute potential stressors. In the *organizational environment* we subsume elements of the physical environment (e.g., furniture design [13]), company culture [29], as well as potential organizational inhibitors of TS experiences (e.g., technical support [5]). Finally, the *social environment* involves users' interactions with other individuals at work which has mostly been studied in the context of social support so far (e.g., support by colleagues in case of technical problems) [32], [42]. In addition to serving as a source of support, the social environment, as conceptualized by Edwards [23], can also be a major determinant of an individual's perceptions and desires (e.g., colleagues with seniority).

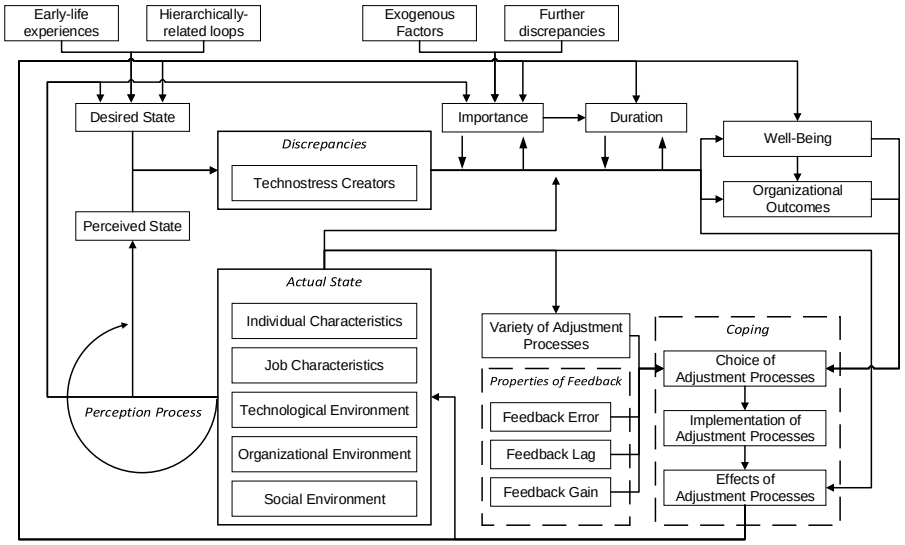

Figure 2. Integrated Theoretical Framework of Technostress Based on Cybernetics

The perception of the actual state (i.e., the perceived state) is then compared to the reference criterion provided by the individual side of the comparison, which is needed to determine a discrepancy leading to strain in the individual. Here, Cummings and Cooper include the individual's preferred state, which, in turn, is determined by the individual's hierarchy of values. Edwards instead directly includes an individual's

desires which are conceptualized as distinct from biological needs (because they are consciously processed). Yet, he also acknowledges that these desires are ordered hierarchically, creating a multitude of interrelated feedback loops where superordinate loops (i.e., loops based on more consciously processed desires related to the ideal self as reference criterion) can activate discrepancies in subordinate loops (i.e., loops based on desires related to general principles such as regular work attendance as reference criterion). Further, although Edwards states that desires are mainly formed by early life experiences, they are primarily dynamic in nature being altered by coping attempts and the social environment of an individual (e.g., opinions of colleagues).

The comparison between the desired state and the perceived state reveals possible discrepancies, which constitute potential sources of stress. However, Cummings and Cooper express their doubts concerning this comparison process (involving the desired state and a perceived state) by an individual, as it is unlikely that the necessary assessment information is coded similarly. Edwards, in this context, argues that the detection of strain is mostly an intuitive assessment and less a mechanical subtraction, highlighting that individuals have the ability to directly sense a discrepancy; note that it is nevertheless difficult for individuals to report such discrepancies, a fact that suggests that discrepancies should *not* be measured with difference score measures [45].

In this context, it is important to note that the difference between perceived state and desired state alone does not always lead to the identification of discrepancies, predominantly because desires can occur in different forms [23]. For example, desires related to the actual state might be represented as minimum or maximum values (e.g., the maximal workload an individual accepts), a certain range of values (e.g., the range of temperature an individual accepts at the workplace), a value that is desired to be either higher or lower without specific thresholds (e.g., no system breakdown is better than one or more breakdowns), or even as an optimal point (e.g., the ideal number of hours an individual wants to work per week).

Research into potential TS-related discrepancies has led to the identification of *TS creators*. The six major categories of TS creators discussed in extant TS research include (e.g., [5], [10], [11], [14], [25], [28], and especially [30], p. 117]):

- Techno-Overload: “Too much” (users face information overload and multitasking),
- Techno-Invasion: “Always connected” (users never feel “free” of ICT),
- Techno-Complexity: “Difficult” (users find it intimidating to learn and use ICT),
- Techno-Insecurity: “Uncomfortable” (users feel insecure about their jobs in the face of new ICT and others who might know more about these technologies),
- Techno-Uncertainty: “Too often and unfamiliar” (users feel unsettled by continual upgrades and accompanying software and hardware changes), and
- Techno-Unreliability: “Too unstable” (users face system malfunctions and other IT hassles).

Discrepancies (TS creators) and the expectation of stress (referred to as threat in the Cummings and Cooper model) activate coping behaviors (i.e., actions directed at resolving discrepancies) and may also lead to detrimental effects. These detrimental effects can be directly related to the well-being of an individual, including mental health with symptoms such as anxiety [42], physical well-being related to increased

levels of stress hormones [10], [12], [25], and psychophysiological reactions [12], [14], [25]. In addition to effects of TS on well-being, Ragu-Nathan et al. [5] have also shown that TS can affect a number of organizational dimensions, and Riedl [3] indicated that these organizational outcomes are probably mediated by negative effects of TS on an individual's well-being. Generally, research on these organizational outcomes has been a major focus in past TS research, leading to the conclusion that many dimensions which are relevant to the success of an organization can be negatively affected by TS, including job satisfaction, [25], [30] or productivity [28], [30].

In the case of acute strain, discrepancies usually directly harm well-being first, before leading to a response, thus activating coping indirectly. The significance of these strains, in addition to the degree of discrepancy between desired and perceived state, is also moderated by the importance and duration of discrepancies in Edwards' model. Determinants of importance are exogenous factors like social information (e.g., a supervisor's opinion on the importance of a task), and the potential of a discrepancy to cause further discrepancies (e.g., a computer breakdown leading to task delay), while duration reflects an individual's awareness of a discrepancy (i.e. how long he/she thinks about it), and is, in turn, affected by the importance of a discrepancy. Moreover, elements of the actual state can also moderate the relationship between TS creators and strains. For example, an individual's working memory capacity (WMC), defined as "people's capacity to process the information necessary to complete an active task" [46], may moderate the impact of techno-overload on fatigue. Just and Carpenter [47], in a seminal paper, discuss individual differences in WMC, an effect that is highly relevant in the context of TS (e.g., larger WMC reduces the incidence of techno-overload); note that differences in WMC may also explain the elderly's increased perceptions of TS, because WMC decreases with age [46].

Coping (Figure 2, right bottom corner) refers to all efforts to prevent, or at least reduce, the negative effects of stress on well-being and/or organizational outcomes, which Edwards groups into four main types: attempts to change the actual state, adjustment of desires to conform to perceptions, reduction of the importance associated with discrepancies, and direct improvement of well-being (e.g., by means of relaxation techniques). TS research has also shown that effective coping mechanisms exist on an organizational level, including well-designed breaks during computer work [15], stress management trainings [25], or technical support [5], [30].

With respect to coping efforts, the Cummings and Cooper model offers a number of specific insights that foster understanding of the selection of coping measures. Specifically, the model by Cummings and Cooper draws upon the Law of Requisite Variety by Ashby [38], which essentially states that an individual can only cope with as many stressors as he/she has responses for. This cybernetic principle not only highlights the importance of an individual's resources for coping, but also highlights that there has to be a fit between a discrepancy's complexity (i.e., the variety of encountered stressors in a given context) and an individual's response complexity (i.e., the variety of an individual's adjustment processes). Therefore, the choice of appropriate adjustment processes is limited by an individual's repertoire of possible responses.

In addition, the properties of feedback may significantly affect selection of coping measures, including misperceptions when appraising the current situation (i.e., feed-

back error), the time it takes until feedback affects the individual (i.e., feedback lag), and the extent to which adjustment processes reduce strain (i.e., feedback gain) [37].

Once a specific coping behavior has been selected, it has to be implemented. However, this implementation may result in effects that are different from the individual's intentions. This discrepancy between actual and intended effects, as asserted by Cummings and Cooper, can be caused by environmental factors (e.g., social environment) affecting the efficacy of implemented coping behaviors. Imagine, for example, that a user who is confronted with a system breakdown and who decides to take a short coffee break to "cool down" discovers that no coffee beans are left in the machine and that the previous user of the coffee machine has not undertaken the refill.

6 Concluding Remarks

We believe that the application of our integrated theoretical framework in future IS studies promises to reveal significant new insights into organizational TS. Based on an application of the framework, new theoretical propositions can be derived (theory focus), the model can be tested in the field (empirical focus), and research design decisions can be made (methodological focus). One fruitful starting point in TS research based on cybernetics would be to find out how ICT and ICT-supported tasks are ranked among an individual's hierarchy of values and desires. Answering this central question leads to insights into the strains that arise through TS, and how many and which resources an individual is willing to allocate in order to resolve the perceived discrepancy. Stress, coping, and well-being (along with their underlying mechanisms) are concepts that usually never reach a state of equilibrium [9]. It follows that cross-sectional research designs are not appropriate for the empirical investigation of our integrated framework. Rather, longitudinal designs are needed, because TS at t_1 elicits coping mechanisms at t_2, which, in turn, affect TS at t_3, and so on. In their article on stress in organizations, Cummings and Cooper [22] already wrote that "most of our knowledge is based on correlational-type studies, with all the difficulties this implies, especially the limited capacity to predict causal relationships" (p. 412). This statement is also true for contemporary IS TS research (e.g., [4, p. A8], [6, p. 329]).

Another important methodological aspect is to complement traditional survey instruments by both qualitative techniques (e.g., narrative interviews or focus groups) and neurophysiological measurements [48]. Biological measures such as heart rate variability [15], or hormone excretion [12], [25], among others, have already been used successfully in field studies, constituting a valuable basis for future IS TS research based on cybernetics. Generally, following a mixed-methods approach has been depicted in the behavioral sciences as a viable alternative to using either qualitative or quantitative methods alone [49], [50]. By using multiple methods of data collection (including those related to perceptual, behavioral, archival, and physiological data sources), one can complement the insights gained from each applied method, or at least get another view on the same phenomenon. This, in turn, can clear the path for new directions of research [51], a fact that is of particular importance in a field with very high societal relevance, such as TS.

References

1. Carayon, P., Smith, M.J., Haims, M.C.: Work organization, job stress, and Work-Related Musculoskeletal Disorders. Human Factors: The Journal of the Human Factors and Ergonomics Society 41, 644–663 (1999)
2. World Health Organization: Global health risks. Mortality and Burden of Disease attributable to selected Major Risks. World Health Organization, Geneva, Switzerland (2009)
3. Riedl, R.: On the Biology of Technostress: Literature Review and Research Agenda. DATA BASE for Advances in Information Systems 44, 18–55 (2013)
4. Ayyagari, R., Grover, V., Purvis, R.: Technostress: Technological Antecedents and Implications. MIS Quarterly 35, 831–858 (2011)
5. Ragu-Nathan, T.S., Tarafdar, M., Ragu-Nathan, B.S., Tu, Q.: The Consequences of Technostress for End Users in Organizations: Conceptual Development and Empirical Validation. Information Systems Research 19, 417–433 (2008)
6. Tarafdar, M., Tu, Q., Ragu-Nathan, T.S.: Impact of Technostress on End-User Satisfaction and Performance. Journal of Management Information Systems 27, 303–334 (2010)
7. Weil, M.M., Rosen, L.D.: TechnoStress. Coping with Technology @Work @Home @Play. Wiley, New York (1997)
8. Wiener, N.: Cybernetics. Or, Control and Communication in the Animal and the Machine. The Technology Press/Wiley, New York (1948)
9. Edwards, J.R.: A Cybernetic Theory of Stress, Coping and Well-Being in Organizations. The Academy of Management Review 17, 238–274 (1992)
10. Riedl, R., Kindermann, H., Auinger, A., Javor, A.: Technostress from a Neurobiological Perspective - System Breakdown Increases the Stress Hormone Cortisol in Computer Users. Business & Information Systems Engineering 4, 61–69 (2012)
11. Tarafdar, M., Tu, Q., Ragu-Nathan, B., Ragu-Nathan, T.: The Impact of Technostress on Role Stress and Productivity. Journal of Management Information Systems 24, 301–328 (2007)
12. Korunka, C., Huemer, K., Litschauer, B., Karetta, B., Kafka-Lützow, A.: Working with new Technologies: Hormone Excretion as an Indicator for sustained Arousal. A Pilot Study. Biological Psychology 42, 439–452 (1996)
13. Johansson, G., Aronsson, G.: Stress reactions in computerized administrative work. Journal of organizational behavior 5, 159–181 (1984)
14. Riedl, R., Kindermann, H., Auinger, A., Javor, A.: Computer Breakdown as a Stress Factor during Task Completion under Time Pressure: Identifying Gender Differences Based on Skin Conductance. Advances in Human-Computer Interaction, 1–8 (2013)
15. Boucsein, W., Thum, M.: Design of Work / Rest Schedules for Computer Work based on psychophysiological Recovery Measures. International Journal of Industrial Ergonomics 20, 51–57 (1997)
16. Adam, M.T.P., Gimpel, H., Maedche, A., Riedl, R.: Stress-Sensitive Adaptive Enterprise Systems: Theoretical Foundations and Design Blueprint. In: Davis, F., Riedl, R., Vom Brocke, J., Léger, P.-M., Randolph, A. (eds.) Proceedings of the Gmunden Retreat on NeuroIS 2014, pp. 39–40 (2014)
17. Lazarus, R.S.: Psychological Stress and the Coping Process. McGraw Hill, New York (1966)

18. French, J.R.P., Caplan, R.D., Harrison, R.V.: The Mechanisms of Job Stress and Strain. Wiley, Chichester, New York (1982)
19. Selye, H.: A Syndrome produced by Diverse Nocuous Agents. Nature 138, 32 (1936)
20. Sonnentag, S., Frese, M.: Stress in Organizations. In: Weiner, I.B. (ed.) Handbook of Psychology. John Wiley & Sons, Inc, Hoboken, NJ, USA (2003)
21. Carver, C.S., Scheier, M.F.: Control Theory: A Useful Conceptual Framework for Personality-Social, Clinical and Health Psychology. Psychological Bulletin 92, 111–135 (1982)
22. Cummings, T.G., Cooper, C.L.: A Cybernetic Framework for Studying Occupational Stress. Human Relations 32, 395–418 (1979)
23. Edwards, J.R.: Cybernetic Theory of Stress, Coping and Well-Being. In: Cooper, C.L. (ed.) Theories of organizational stress, pp. 122–152. Oxford University Press, Oxford, New York (1998)
24. Johansson, G., Aronsson, G., Lindstrom, B.O.: Social Psychological and Neuroendocrine Stress Reactions in Highly Mechanised Work. Ergonomics 21, 583–599 (1978)
25. Arnetz, B.B.: Techno-Stress: A Prospective Psychophysiological Study of the Impact of a Controlled Stress-Reduction Program in Advanced Telecommunication Systems Design Work. Journal of Occupational and Environmental Medicine 38, 53–65 (1996)
26. Arnetz, B.B., Berg, M.: Melatonin and Adrenocorticotropic Hormone Levels in Video Display Unit Workers During Work and Leisure. Journal of Occupational and Environmental Medicine 38, 1108–1110 (1996)
27. Shu, Q., Tu, Q., Wang, K.: The Impact of Computer Self-Efficacy and Technology Dependence on Computer-Related Technostress: A Social Cognitive Theory Perspective. International Journal of Human-Computer Interaction 27, 923–939 (2011)
28. Tu, Q., Wang, K., Shu, Q.: Computer-related Technostress in China. Communications of the ACM 48, 77–81 (2005)
29. Wang, K., Shu, Q., Tu, Q.: Technostress under different Organizational Environments: An empirical Investigation. Computers in Human Behavior 24, 3002–3013 (2008)
30. Tarafdar, M., Tu, Q., Ragu-Nathan, T.S., Ragu-Nathan, B.S.: Crossing to the dark side. Examining Creators, Outcomes, and Inhibitors of Technostress. Communications of the ACM 54, 113–120 (2011)
31. Lazarus, R.S., Folkman, S.: Stress, Appraisal, and Coping. Springer Pub. Co., New York (1984)
32. Wastell, D., Newman, M.: The behavioral Dynamics of Information System Development: A Stress Perspective. Accounting, Management and Information Technologies 3, 121–148 (1993)
33. McGrath, J.E.: Stress and Behavior in Organizations. In: Dunnette, M.D. (ed.) Handbook of industrial and organizational psychology, pp. 1351–1395. Wiley, New York (1983)
34. Wastell, D., Newman, M.: Information System design, Stress and organisational Change in the Ambulance Services: A Tale of two Cities. Accounting, Management and Information Technologies 6, 283–300 (1996)
35. Wastell, D.G., Newman, M.: Stress, Control and Computer System Design: A psychophysiological Field Study. Behaviour & Information Technology 15, 183–192 (1996)
36. Karasek, Robert A. Jr.: Job Demands, Job Decision Latitude, and Mental Strain: Implications for Job Redesign. Administrative Science Quarterly 24, 285–308 (1979)

37. Cummings, T.G., Cooper, C.L.: A Cybernetic Theory of Organizational Stress. In: Cooper, C.L. (ed.) Theories of organizational stress, pp. 101–121. Oxford University Press, Oxford, New York (1998)
38. Ashby, R.W.: An Introduction to Cybernetics. Chapman & Hall, London (1957)
39. Liang, H., Xue, Y.: Avoidance of Information Technology Threats: A Theoretical Perspective. MIS Quarterly 33, 71–90 (2009)
40. Frone, M.R., McFarlin, D.B.: Chronic Occupational Stressors, Self-Focused Attention, and Well-Being: Testing a Cybernetic Model of Stress. Journal of Applied Psychology 74, 876–883 (1989)
41. Miller, J.G.: Living Systems: Basic Concepts. Behavioral Science 10, 193–237 (1965)
42. Salanova, M., Llorens, S., Cifre, E.: The dark Side of Technologies: Technostress among Users of Information and Communication Technologies. International Journal of Psychology 48, 422–436 (2013)
43. Maier, C., Laumer, S., Eckhardt, A., Weitzel, T.: Giving too much Social Support: Social Overload on Social Networking Sites. European Journal of Information Systems, 1–18 (2014)
44. Hudiburg, R.A.: Psychology of Computer Use: XXXIV. The Computer Hassles Scale: Subscales, Norms, and Reliability. Psychological Reports 77, 779–782 (1995)
45. Johns, G.: Difference Score Measures of organizational Behavior Variables: A Critique. Organizational Behavior and Human Performance 27, 443–463 (1981)
46. Tams, S.: Clashing Trends: Probing the Role of Age in Technostress. In: Davis, F., Riedl, R., Vom Brocke, J., Léger, P.-M., Randolph, A. (eds.) Proceedings of the Gmunden Retreat on NeuroIS 2014, p. 35 (2014)
47. Just, M.A., Carpenter, P.A.: A Capacity Theory of Comprehension: Individual Differences in Working Memory. Psychological Review 99, 122–149 (1992)
48. Tams, S., Hill, K., Ortiz de Guinea, A., Thatcher, J., Grover, V.: NeuroIS - Alternative or Complement to Existing Methods? Illustrating the Holistic Effects of Neuroscience and Self-Reported Data in the Context of Technostress Research. Journal of the Association for Information Systems 15, 723–753 (2014)
49. Tashakkori, A., Teddlie, C. (eds.): Handbook of mixed methods in social & behavioral research. SAGE Publications, Thousand Oaks, Calif (2003)
50. Creswell, J.W.: Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications, Thousand Oaks, Calif (2003)
51. Venkatesh, V., Brown, S.A., Bala, H.: Bridging the qualitative-quantitative Divide:Guidelines for conducting Mixed Methods Research in Information Systems. MIS Quarterly 37, 21–54 (2013)