

# The Status Quo of Neurophysiology in Organizational Technostress Research: A Review of Studies Published from 1978 to 2015

Thomas Fischer and René Riedl

**Abstract** We report on the status quo of neurophysiology in organizational technostress research, showing how neurophysiological tools have been applied in technostress studies with a focus on the organizational level of analysis. Based on a review of research published in peer-reviewed journals, we found that neurophysiological tools have seen relatively frequent application, particularly in early technostress studies (1970–1990s), but have since then been on the decline. We also found that contemporary organizational technostress research relies heavily on survey-based approaches to study the nature, causes, and effects of this phenomenon, almost completely neglecting prior successful applications of neurophysiological tools.

**Keywords** Technostress • Measurement • Review • Organization • Stress • NeuroIS

## 1 Technostress and Neurophysiology

With the advent of information and communication technologies (ICT) it has become clear that individuals and organizations can not only benefit from the application of ICT, but that there is also a negative side of ICT use (e.g., [1]). One major negative aspect of ICT use is *technostress* (e.g., [1–4]), a phenomenon that can arise 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” [1]. Though researchers had started to investigate

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this phenomenon empirically (e.g., [5, 6]) even before the term “technostress” was coined in a publication in 1982 [7], it has received increased attention from IS researchers in the more recent past (e.g., with publications in mainstream journals such as *MIS Quarterly*, *Information Systems Research*, *Journal of Management Information Systems*, or *Journal of the Association for Information Systems*). This increased level of IS publication is not surprising due to several technological developments (e.g., mobile technologies) that are likely related to user stress. Thus, technostress is a phenomenon of high prevalence in modern society, and it may have detrimental effects (e.g., affecting personal well-being with symptoms such as anxiety [8, 9], fatigue [9, 10] or exhaustion [2], or work-related outcomes such as reduced job satisfaction [3, 10–14], reduced performance [10, 13, 15], or reduced organizational commitment).

To investigate these effects and the occurrence of technostress in general, neurophysiological tools are essential in order to gain a more complete understanding of the phenomenon. It has been shown, for example, that subjective reports of the experience of technostress alone are not sufficient, as actual physiological stress reactions can deviate significantly from individual accounts (e.g., [1, 10, 16]).

As technostress is a phenomenon that results from the interplay between the individual and the environment (e.g., [17, 18]), focusing on the individual level of analysis alone (e.g., through experimentation in laboratory settings) limits the generalizability of research findings (external validity issue). Presumably due to the complexity of neurophysiological measurement, application of neurophysiological tools has been avoided at all, or neurophysiological studies of technostress have so far been predominantly conducted in laboratory settings [1]. Thus, technostress research applying neurophysiological tools in the field is urgently needed and has already been shown to be a viable option, particularly in early studies (e.g., [5, 6, 10, 11, 19]). In this paper, therefore, we show how technostress research outside of laboratory settings has developed since these early studies. Specifically, we review the different measurement tools which have been applied so far in organizational technostress research.

## 2 Measurement Tools in Technostress Research

Following the research methodology presented in a recent review of technostress research to identify relevant studies ([1], see appendix),<sup>1</sup> we selected peer-reviewed journal articles which focused on technostress in an organizational context (e.g., indicated by the collection of data from individuals in their roles as professionals acting in organizational settings, e.g., [15]). This process of research and

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<sup>1</sup>Google Scholar search of the term “technostress” on 02/13/2015. Note though that we did not formulate the requirement that a publication must have at least five citations to be included in our study (see [18]).

subsequent selection led to the identification of a total of 25 journal articles which were then used as the basis for this review [2–6, 9–15, 19–31].

When focusing on the chronology and publication outlets, we found that there have been two major periods of technostress research so far. The first period of intensified research started in the beginning of the 1990s and stretched throughout that decade, with research being mainly published in non-IS journals (e.g., journals related to medicine or psychology) [10–12, 19–23]. The second major period of technostress research started in the last decade and is ongoing until today. Unlike the studies in the preceding period of research, contemporary technostress articles have mainly been published in IS journals [2, 4, 9, 13–15, 24–31].

As shown in Table 1, we observe significant differences with regard to the measurement tools that have been applied in extant literature on organizational technostress research. We identified the application of four main data sources: (A) surveys, (B) interviews, (C) physiological data, and (D) hormones and related biological substances. We found significant differences in types of collected data between research published in the 1990s and before that period and research published in the 2000s and after that period.

Surveys (A) have been applied frequently, mainly in order to measure the perceptual components involved in the experience of technostress. This focus can be attributed to the essential role of individual perceptions in the occurrence of technostress-related discrepancies (e.g., discrepancy between the perceived reliability of computer systems and the desired reliability of computer systems), though it is not sufficient to investigate technostress perceptions alone (e.g., [32]). Interviews (B), in contrast, were mainly used to assess the viability of existing or newly developed measurement scales (e.g., [2, 14]), or as complementing data sources (e.g., [23, 26]).

The measurement of physiological data (C), such as cardiovascular activity (e.g., [10]) or electro-dermal activity (e.g., [19]), and the measurement of the excretion of hormones (D)<sup>2</sup> such as cortisol (e.g., [10]) or adrenaline (e.g., [11]), were commonly applied in early field studies. Interestingly, despite the substantial research basis published in early studies, we found no journal publications that were published after 1997 which reported on an empirical study (conducted in an organizational setting) applying neurophysiological tools of the categories (C) and (D).

Moreover, brain-imaging tools, an equally important category of measurement tools in NeuroIS research (e.g., [34–38]), have not been applied in any technostress field study thus far. This research gap can be partially explained by the characteristics of brain-imaging tools (e.g., lack of mobility of some tools or their low accessibility in certain areas, [37]), which complicate their application in the field or even render application impossible (e.g., in the case of magnetic resonance imaging). However, the advent of brain-imaging tools which can be applied in field

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<sup>2</sup>Though the measurement of hormones and related biological substances (D) could be subsumed in category (C) as another source of physiological data, we created an own category for this data source due to differences in the underlying research methodology (for details, see a recent paper by Riedl et al. [33]).

**Table 1** Main measurement tools applied in organizational technostress research

Years	References	A	B	C	D
1970s–1990s	Johansson et al. [5]	X	X	X	X
	Johansson and Aronsson [6]	X	X	X	X
	Berg et al. [20]; Arnetz and Berg [21]	X	X		X
	Arnetz [11]	X		X	X
	Korunka et al. [10]	X		X	X
	Wastell and Newman [22, 23]	X	X	X	
	Arnetz and Wiholm [12]	X			X
	Boucsein and Thum [19]	X		X	
	Tu et al. [24]	X			
	Tarafdar et al. [4, 13, 14]	X	X		
2000s–2015	Ragu-nathan et al. [3]	X	X		
	Wang et al. [25]	X			
	Ayyagari et al. [2]	X	X		
	Barley et al. [26]	X	X		
	Shu et al. [27]	X	X		
	Salanova et al. [9]	X			
	D’Arcy et al. [28]	X	X		
	Sellberg and Susi [29]	X			
	Tarafdar et al. [15, 31]	X			
	Maier et al. [30]	X			

We merged (i) [20, 21], (ii) [22, 23], (iii) [4, 13, 14], (iv) [15, 31] because they share the same empirical basis. (A) surveys, (B) interviews, (C) physiological data, and (D) hormones and related biological substances

settings more flexibly, such as near-infrared spectroscopy (NIRS) (e.g., [39, 40]) or electroencephalography (EEG) (e.g., [41]), indicate significant research potential in this area.

Overall, it seems that a gap regarding the application of neurophysiological tools in organizational technostress studies has emerged in contemporary research. Therefore, in the next section, we will briefly show which neurophysiological measures have been utilized successfully in early technostress research (i.e., period 1970–1990s, see Table 1), in order to foster their more frequent application in future studies.

### 3 Neurophysiological Tools in Early Technostress Research

As a result of a more detailed review of studies which applied measurement tools included in categories (C) and (D) (see Table 1), we created an overview of all neurophysiological measures that have been applied in organizational technostress research so far (see Table 2). Physiological measures (C) that have been applied most frequently are related to cardiovascular activity such as heart rate and blood pressure, while other measures were used less frequently (i.e., body temperature, electrodermal activity, and neck electromyogram). Moreover, measures of ocular activity (e.g., eye movements or pupil dilation) or facial muscular activity (which can be an indicator for emotional valence) were not applied at all, even though they have been introduced as viable tools for NeuroIS studies (e.g., [37, 38]).

Hormones and related substances (D) which played a significant role in prior research are mainly stress hormones such as catecholamines (e.g., adrenaline and noradrenaline) and cortisol, and sex hormones such as estradiol or testosterone. Further, prolactin has been shown to be a viable alternative to these substances, as it can also be good indicator of mental and physical arousal [10]. Importantly, studies like the ones by Berg et al. [42] or Arnetz and Berg [21] have demonstrated that there is a wide variety of additional substances that can be measured when assessing the effects of technostress. However, to analyze these substances in most cases blood samples have to be drawn (except for substances such as catecholamines and cortisol which can be measured via urine and saliva samples, e.g., [5, 6, 10]). As blood cannot be collected non-invasively, in contrast to urine or saliva samples, the NeuroIS researcher might perceive a boundary, preventing scholars from collecting blood samples.

Although our results indicate that there is a gap in technostress studies applying neurophysiological tools in the field, neurophysiological tools have been applied in several IS laboratory studies in recent years. For example, Riedl et al. [43] have shown that cortisol excretion significantly increased in response to a system breakdown and, in a follow-up study [44], demonstrated gender differences in reactions to system breakdown based on electrodermal activity. Also, Tams et al. [16], to mention another recent study, demonstrated that measuring the salivary

Table 2 Neurophysiological tools applied in organizational technostress research

	Johansson et al. [5]	Johansson and Aronsson [6]	Berg et al. [20], Arnetz and Berg [21]	Ametz [11]	Korunka et al. [10]	Wastell and Newman [22, 23]	Arnetz and Wiholm [12]	Boucsein and Thum [19]
<i>Physiological measures</i>								
Blood pressure		X		X	X	X		
Body temperature	X							
Electrodermal activity								X
Heart rate		X		X	X	X		X
Neck electromyography								X
<i>Hormones and related substances</i>								
ACTH levels			X					
Catecholamines <sup>a</sup>	X	X	X		X			
Cortisol			X	X	X			
Estradiol			X					
Growth hormone			X					
Melatonin			X					
Prolactin			X	X			X	
Testosterone			X	X				
Thyroxin			X					
Related substances <sup>b</sup>				X				

<sup>a</sup> Under “Catecholamines” we subsume Adrenaline (Epinephrine) and Noradrenaline (Norepinephrine)

<sup>b</sup> Substances which can also be measured when analyzing hormone levels; examples are: Albumin, Apolipoprotein A1 and B, Cholesterol, and Fructosamine

excretion of  $\alpha$ -amylase can be a valuable addition to the biological measurement of technostress levels.

Despite the lack of NeuroIS field studies in the domain of technostress research it can therefore be acknowledged that neurophysiological tools are readily applied. However, in order to increase the external validity of existing insights, applications of these tools in more natural settings (e.g., field studies in organizations) should be a valuable extension to contemporary research practices. It will be rewarding to see what insight future research will reveal.

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