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RESEARCH ARTICLE

TECHNOSTRESS: TECHNOLOGICAL ANTECEDENTS AND IMPLICATIONS[1]

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With the proliferation and ubiquity of information and communication technologies (ICTs), it is becoming imperative for individuals to constantly engage with these technologies in order to get work accomplished. Academic literature, popular press, and anecdotal evidence suggest that ICTs are responsible for increased stress levels in individuals (known as technostress). However, despite the influence of stress on health costs and productivity, it is not very clear which characteristics of ICTs create stress. We draw from IS and stress research to build and test a model of technostress. The person–environment fit model is used as a theoretical lens. The research model proposes that certain technology characteristics—like usability (usefulness, complexity, and reliability), intrusiveness (presenteeism, anonymity), and dynamism (pace of change)—are related to stressors (work overload, role ambiguity, invasion of privacy, work–home conflict, and job insecurity). Field data from 661 working professionals was obtained and analyzed. The results clearly suggest the prevalence of technostress and the hypotheses from the model are generally supported. Work overload and role ambiguity are found to be the two most dominant stressors, whereas intrusive technology characteristics are found to be the dominant predictors of stressors. The results open up new avenues for research by highlighting the incidence of technostress in organizations and possible interventions to alleviate it.

Keywords: Technostress, ICTs, information and communication technologies, stress, technology characteristics, strain, stressors

Introduction

Information and communication technologies (ICTs) pervade work as well as personal lives in the 21st century. Organizations have gained great advantages in productivity efficiencies and effectiveness of their workers (Brynjolfsson and Hitt 1996; Dos Santos and Sussman 2000; Kudyba and Diwan 2002) through the implementation and assimilation of ICTs. But have these gains come at a cost? We argue that the costs of using ICTs are not always apparent. For example, from an individual point of view, there are no apparent costs in multiplying the number of e-mails by "copying to all" versus simply replying to an e-mail. Should a manager encourage group members to be available through ICTs during nonwork hours? Should strict work-home boundaries be discouraged? Should an organization mandate use of wireless e-mail

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devices to enhance corporate communication? Should instant responses from project members be expected?

While the naïve response to these questions might be in the affirmative based on the presumption of enhanced productivity, there could be unintended consequences of these ICTs that could be counterproductive. Consider the use of mobile e-mail devices like BlackBerrys® and iPhones®. Initial enthusiasm in having anywhere e-mail and expected productivity gains have driven the exponential growth in these devices. However, BlackBerrys are now referred to as "CrackBerrys" in popular literature and even initial academic research on the use of these devices identifies that there can be unintended consequences like stress and antisocial behavior (Mazmanian et al. 2006; Middleton and Cukier 2006). Which gadgets will it be tomorrow? What is it about these ICTs that could lead to such unintended consequences? Our focus is on an important unintended consequence: the *stress* caused by ICTs. By characterizing these technologies and examining their impact on stress, we hope to open up new avenues for more informed adoption decisions.

The term *technostress* was coined in 1984 by clinical psychologist Craig Brod, who described it as a modern disease caused by one's inability to cope or deal with ICTs in a healthy manner. Stress in the workplace is recognized as contributing to a litany of health and quality-of-life issues that could have far reaching consequences (Cooper et al. 1996; Sutherland and Cooper 1990; Tennant 2001). The World Health Organization (WHO) argues that present work patterns have changed partly due to the increased use of ICTs (WHO 2005). They claim that most of the organizational responses to "prevent and eliminate health risks at the workplace were primarily directed at physical risks and largely ignored psychosocial risks and the effects of work on mental health" (p. 3), and suggest that trained personnel and tools are required to develop preventive measures to reduce the risks posed to workers' mental health. We offer a framework as one such tool that provides guidance on the impacts of technologies on workers' mental health.

Indeed, computerization of the office work environment is shown to have higher levels of stress among employees (Agervold 1987; Kinman and Jones 2005; Korunka and Vitouch 1999; Wittbecker 1986). While some have argued that this increase is due to heavier workloads (Aborg and Billing 2003, Sandblad et al. 2003; Wittbecker 1986), it is most likely a combination of effects. The use of ICTs has produced a perpetual urgency and creates expectations that people need, or are obligated, to work faster (Hind 1998). Straub and Karahanna (1998) argue that technostress likely comes from the fragmentation of work. Globalization and the fierce competitive nature of business has created lean organizations with cultures that reward people who work exceptionally hard, spend longer hours at work, and are connected to the organization 24/7 via ICTs (Kouzmin and Korac-Kakabadse 2000; Spruell 1987). Stressed IT professionals are linked to issues of organizational commitment, turnover intentions, and work exhaustion (Ahuja et al. 2007; Moore 2000).

Although the stress research area is broad, technostress has not been extensively studied.[2] Two recent studies have emphasized the importance of technostress by studying the impacts of technostress (Ragu-Nathan et al. 2008; Tarafdar et al. 2007). These studies have found that individuals experiencing technostress have lower productivity and job satisfaction, and decreased commitment to the organization. Although these studies establish the importance of technostress, it is not clear which characteristics of technology create stress. This conceptualization essentially black boxes the technostress phenomenon, making the boundaries and relationship between technology characteristics and stress ambiguous. For example, one of the dimensions used to capture technostress is techno-overload, which asserts that there is greater workload and this is caused by technology. However, it is not clear what characteristics of technology are causing this increase in workload. In the current study, we make this clear by explicitly identifying technology characteristics and their relation to stress. Furthermore, there are calls for research in both the stress and the IS literature to study the stressful impacts of (1) ICT use and (2) new work arrangements enabled by ICTs (Cooper et al. 2001; Weber 2004). Given the practical significance and research relevance, it is important to understand technology-induced stress at the workplace. The research goal of this study is *to investigate the role of technology characteristics in inducing stress in individuals.*

To understand ICT-induced stress, it is important to identify manifestations of the technologies themselves. What is it about technologies that ultimately leads to stress? Unfortunately, most of the existing literature on technostress (Brod 1984; Sami and Pangannaiah 2006; Weil and Rosen 1997), while useful in its descriptiveness, provides very little insight into technology characteristics. For instance, Weil and Rosen (1997) describe technostress using concepts such as "space invasion" as a source of stress. Such concepts do not reflect the characteristics of ICTs (e.g., constant connectivity) and their role in the manifestation of technostress. The need for deeper investigation of the IT artifact is further supported by

[2]It should be noted that the sizable stress-related research in IS mainly focuses on stress experienced by IS professionals (e.g., Ahuja et al. 2007; Moore 2000), not on how technology can be a source of stress.

Nelson (1990), who urges researchers to study specific characteristics of technology rather than treating technology in an undifferentiated manner. Therefore, rather than treating technology as a surrogate for factors existing at various levels and units of analyses, the present study delineates the technology characteristics that engender stress—with the intent of providing a superior understanding of the phenomenon of technostress.

As shown in Figure 1, the broad model for this research has three sets of variables: technology characteristics,[3] stressors, and the ultimate manifestation of stress (strain). The model is developed in subsequent sections with a review of the relevant background on stressors from the stress literature followed by development of technology characteristics and associated hypotheses. Research methods, various data analyses, and results are then presented. We conclude by discussing the results and implications for research and practice.

Background

Two broad theoretical paradigms shed light on stress phenomenon. The first paradigm could be labeled an epidemiological perspective (Fox et al. 1993). Researchers using this view typically link occupational conditions such as workload or vibration to actual disease manifestations such as coronary heart disease. Advocates of this view argue for the use of objective measures for gauging stressors and their outcomes. The other paradigm could be labeled a cognitive perspective (Fox et al. 1993). This view emphasizes that stressful outcomes are determined by how people cognitively interpret or appraise environmental demands. The outcomes studied in the cognitive perspective are mainly psychological and advocates of this view argue for the use of subjective measures, such as individual perceptions of occupational demands. While there are inconsistencies in terminology used in stress research (Jex et al. 1992), there is a growing consensus for viewing stress as neither emerging from the individual nor the environment, but as a phenomenological process reflected in the relationship between the two (Lazarus 1990). Stress arises when an individual appraises the demands placed by the environment as exceeding the individual's resources, thereby threatening the individual's well-being (Cooper et al. 2001; Lazarus 1991). This overall transactional process is referred to as *stress*. Stressors are the stimuli encountered by the individual, and *strain* is defined as an individual's psychological response to the stressors (Cooper et al. 2001) (Table 1). Below, we describe the person–environment (P-E) fit model as an appropriate theoretical lens to study technostress.

Person–Environment Fit Model

The P-E fit model of stress is one of the most widely used models in stress research (Cooper et al. 2001; Edwards 1991; Edwards and Cooper 1988). This model is based on the premise that there is an equilibrium relationship between people and their environment (the context around the individual). When this relationship is out of equilibrium, it results in strain. This simple but powerful idea of P-E fit holds a central position in stress research and is reflected in other frameworks of stress (Edwards et al. 2000; Eulberg et al. 1988). Specifically, the lack of fit or the gap between the characteristics of the person and the environment could lead to unmet individual needs or unmet job demands that result in strain (Cooper et al. 2001). This view emphasizes the subjective evaluation of the P-E fit (i.e., how the individual *perceives* the situation) or misfit.

Broadly, the concept of P-E fit could be approached in two distinct ways: the reductionist approach and the gestalt approach (Dawda and Martin 2001; Edwards et al. 2006; Kristof-Brown et al. 2005). In the reductionist approach, both the person and the environment dimensions are considered separately and then these two dimensions are combined to obtain a measure of (mis)fit, whereas in the gestalt approach a direct measure of (mis)fit or congruence is obtained. Recent studies have argued that the differences in approaches go beyond the measurement space (Edwards et al. 2006; Kristof-Brown et al. 2005). A recent meta-analysis on P-E fit identifies both of these approaches as being widely used and argues that the appropriate approach should be used based on the research question (Kristof-Brown et al. 2005).

Irrespective of the approach used, a misfit or gap could occur in two ways (Edwards 1996). First, a misfit could occur between the values of a person and the environmental supplies available to fulfill those values (Edwards 1996). Typically, values represent conscious desires held by the person and encompass preferences and interests (Edwards 1996; Edwards and Cooper 1990; French et al. 1982). Given

[3]The term *technology characteristics*, literally taken, refers to attributes or features of a particular ICT. However, as individuals use the ICTs, we believe it is important to consider how they see the ICTs rather than what the ICTs are comprised of. Do they see ICTs as reliable, useful, etc., or do they see them as a bunch of technical features? If an average user uses a laptop, does he consider it faster, more reliable, etc., or does he care about technical features such as type of processor or hard drive? We believe users' perceptions about technology are aligned more with their *assessments of technology characteristics*. Therefore, we believe the appropriate term for technology characteristics would be *assessment of technology characteristics*. However, we use technology characteristics in this manuscript for the purpose of brevity.

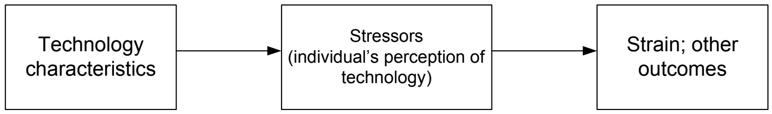

Figure 1. Research Model in This Study

Table 1. Description of Stress-Related Terms

Concept/Term	Description
Stress	The overall transactional process
Stressors	The events or properties of events (stimuli) encountered by individuals
Strain	The individual's psychological[†] response to the stressors

[†]In this study, we focus on psychological response rather than on physical or behavioral responses.

the individual's preferences, a misfit in terms of subjective evaluation of supplies provided by the environment leads to strain. A typical application of this fit approach is to assess the perceived discrepancy between what the individual wants and what the job provides (Cable and DeRue 2002) or how well the needs of individuals are met by their jobs (Brkich et al. 2002; Cable and DeRue 2002).

A second type of misfit could occur between the abilities of the person and the demands placed by the environment. Abilities could include skills, knowledge, time, and energy. Demands typically refer to the individual's subjective evaluation of the requirements placed on the person. This implies that similar requirements might be interpreted as different demands by different individuals. A typical application of this fit approach is to assess the extent to which the demands of the job exceed an individual's capabilities (Beehr et al. 1976; Chisholm et al. 1983) or if an individual's capabilities are insufficient for the job demands (Schaubroeck et al. 1989; Sutton and Rafaeli 1987). The values–supplies fit and the demands–abilities fit form two complementary approaches (Kristof 1996) and capture the degree to which the person and the environment each provide what the other requires (Edwards 1991; Edwards et al. 2006). The manifestation of these perceived misfits occurs through stressors; eventually they lead to strain.

Sources of Strain (i.e., Stressors) from the Job-Stress Literature

The job-stress literature identifies several factors that are sources of strain within the job environment. Our summary of often-cited stressors follows the categorization proposed by Cartwright and Cooper (1997). The categories identified are characteristics of the job, role characteristics, organizational factors, career concerns, relationships within the organization, and work–home interface. In addition, invasion of privacy is also discussed as a potential stressor (Malhotra et al. 2004). The stressors included in the present study are chosen based on (1) the appropriateness of stressors to the phenomenon under study in the present work[4] and (2) the dominant stressors from that category (if multiple pertinent stressors exist in each category) are selected in order to reduce redundancy.

Table 2 provides (1) categories and listing of potential stressors identified in the literature, (2) comments on why only certain stressors are selected, (3) the stressors used in this study, and (4) their definitions. As shown, five stressors are included in the present study. *Work overload* is the perception that assigned work exceeds an individual's capability or skill level (Cooper et al. 2001; Moore 2000). *Role ambiguity* is the unpredictability of the consequences of one's role performance and lack of information needed to perform the role (Cooper et al. 2001; Jex 1998; Kahn et al. 1964). *Job insecurity* is the perception of the threat of job loss (Ashford et al. 1989; Burke and Cooper 2000; Cooper et al. 2001). *Work–home conflict* is the perceived conflict between the demands of work and family (Cooper et al. 2001; Kreiner 2006; Netemeyer et al. 1996) while *invasion of privacy* involves the perception that an individual's privacy has been compromised (Alge 2001; Eddy et al. 1999). These

[4]For example, the physical characteristics of the job in terms of noise or temperature might not be relevant when considering technostress.

Table 2. Literature Review and Choice of Stressors

Stressor Category	Possible Stressors	Rationale	Stressors Included in the Present Study
Characteristics of Job	• Physical – Noise – Temperature – Vibration • Task Related – Work overload – Work hours – Exposure to risks and hazards	• Physical stessors (noise, etc.) are deemed inappropriate for studying the impact of information technologies. • Work hours is somewhat related to work overload. • Shift work component of work hours and exposure to risks and hazards are controlled through the sample.	Work overload (Perception that assigned work exceeds an individual's capability or skill level)
Role Characteristics	• Role ambiguity • Role conflict • Role overload	• Role overload has considerable overlap with work overload • Role ambiguity is a stronger predictor of strain than role conflict (Jackson and Schuler 1985). Further, it is not clear how technology could affect role conflict.	Role ambiguity (Unpredictability of the consequences of one's role performance and lack of information needed to perform the role)
Relationships Within Organization	• Interpersonal relationships • Leadership style	• Not dominant predictors of strain as compared to other stressors. Further direct impacts of technology are not apparent.	None
Career Issues	• Job insecurity • Career advancement	• Job insecurity is widely studied and the dominant factor in this category.	Job insecurity (An individual's perception of threat of job loss)
Organizational Factors	• Climate • Structure	• Not dominant predictors of strain as compared to other stressors.	None
Work–Home Interface	Work–home conflict	• One of the new stressors fueled by the telework phenomenon.	Work–home conflict (An individual's perceived conflict between the demands of work and family)
Invasion of Privacy	Invasion of privacy	• Growing concern as a cause of strain fueled by advances in ICTs.	Invasion of privacy (Perception that individual's privacy has been compromised)

stressors reflect the misfit along abilities–demands and values–supplies as per the P-E model. For example, the stressor work overload reflects the degree to which work requirements (environmental demands) exceed the individual's abilities.

Technostress deals with stress due to ICTs; however, an individual's work situation could be stressful for several reasons (in addition to technostress). Figure 2 contextualizes this study by showing how it fits into the overall stress model. It is suggested that some of the well-known stressors may be more pronounced with the use of ICTs at work (Frese 1987). For example, the work overload stressor might have a component due to the use of ICTs and other components due to the nature of the job. Since the focus of this study is on technostress, it is important to only consider stressors due to ICTs. Consequently, future references to stressors (i.e., work overload, role ambiguity, invasion of privacy, job insecurity, and work–home conflict) refer to the components of these stressors due to ICTs (e.g., work overload refers to work overload *due to* ICTs).

Technology, Characteristics, Model, and Research Hypotheses

Developing a model with the requisite technology characteristics that is generalizable across various information technologies poses a challenge. To identify the technology characteristics that enhance the person–environment misfit, we used the following procedure. First, based on a review of available studies on technostress, recurrent technology concepts that are proposed to be stressful are identified. Then,

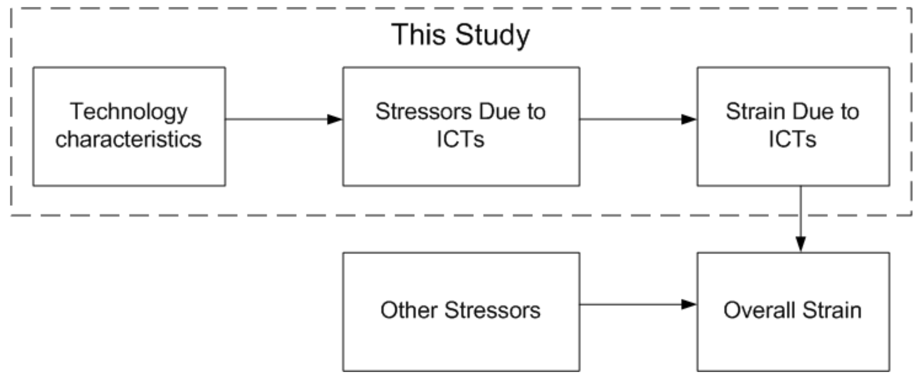

Figure 2. Boundaries of the Present Study

these concepts are mapped onto the available constructs from the IS literature based on their conceptual similarity. We also include illustrative technologies for each technology characteristic. The resulting characteristics, definitions, illustrative technologies, and references are shown in Table 3. In the above process, the first step ensured that the identified concepts of technology are recurrent and prominent in the technostress literature. The second step involved mapping the constructs from IS literature that comprehensively cover concepts from step 1. For example, concepts of *complexity* and *lack of reliability* are recurrent in the technostress literature, so constructs from the IT use and the adoption literature that correspond to these concepts are used.

Usefulness, complexity, and reliability are related to the adoption and use of technologies; we categorize these characteristics as *usability features.*[5] The pace of change relates to the dynamic nature of ICTs, and is referred to as a *dynamic feature*. Finally, presenteeism and anonymity refer to the invasiveness of ICTs and are categorized as *intrusive features*.

It is our contention that the logic of the P-E framework provides insight into *how* technology characteristics influence stressors. Since we are dealing with the technological environment, the present study could be classified as a study in P-T (person–technology) fit.[6] We use the broader P-E literature as a theoretical background to develop the situation-specific P-T model. Figure 3 illustrates technology characteristics and the impact they have on stressors, referred to as the P-T fit model. Each characteristic can influence the P-T gap by manipulating the individual's ability to deal with the demands. Further, it could also supply attributes that are not consistent with the individual's values, preferences, needs, or expectations. In each case, the evaluation of the extent of gap or misfit by the individual can lead to an increase in the stressors. Ultimately, the individual's evaluation of the gap (which will be influenced by individual characteristics) is the precursor to the stressor.[7] Therefore, in providing the reasoning for the links between ICT characteristics and stressors, we use the logic of the P-T framework. The logic itself is represented by the dashed lines in Figure 3 and is used to develop hypotheses. If the ICT is argued to influence the perception of the P-T gap, it will influence the stressor.

Table 4 identifies all of the technology characteristics used in the study, how the abilities–demands and supplies–values dimensions of P-T are affected, what it means for the P-T gap, and, finally, which stressors are reflected by the P-T gap. The table complements our hypotheses development below. Note that the table only illustrates key influences. The organization below follows the complete research model as shown in Figure 4,[8] with each stressor's link discussed within the broad category of technology characteristics.

[5]Note that this categorization is for presentation purposes only. For example, the reference to *usability features* is **not** a second order factor with usefulness, complexity, and reliability as first order factors, nor do these three constructs exhaustively reflect the *usabiilty* construct from other fields (e.g., human–computer interaction).

[6]This is similar to other applications of P-E fit in the literature; for example, P-O (organization) fit or P-G (group) fit.

[7]This logic is not inconsistent with the TTF model proposed by Goodhue and Thompson (1995). Their model subsumes the "fit" between the individual and the technology as a precursor to improved performance. We would argue that a greater fit of the individual with the technology would reduce the gap between the environmental demands/supplies and the individual abilities/values.

[8]Dashed arrows do not have any special meaning and are used for presentation purposes only.

Table 3. Technology Characteristics

Technology Characteristics Identified		Definition	Illustration of ICTs† (*Example technologies for each characteristic*)	Support for Identified Characteristics from Existing Literature	Review of Existing Studies on Technostress: Ragu-Nathan and Colleagues (2007; 2008)	Kakabadse et al. (2000)	Sami and Pangannaiah (2006)	Tu et al. (2005)	Weil and Rosen (1997)
Usability features	Usefulness	Degree to which characteristics of technology enhance job performance	Generic application technologies (e.g., word processing, spreadsheet, presentation)	Davis et al. (1989) Moore and Benbasat (1991)		✓	✓		✓
	Complexity	Degree to which use of technology is free of effort	Mobile technologies (e.g., cell phone, pager, BlackBerry®, laptop, PDA)	Moore and Benbasat (1991)	✓	✓	✓	✓	✓
	Reliability	Degree to which features and capabilities provided by the technology are dependable	Enterprise and database technologies (e.g., PeopleSoft®, SAP®, Oracle®)	Delone and McLean (1992, 2003) Jiang et al. (2002)	✓	✓		✓	✓
Dynamic feature	Pace of Change	Degree to which an individual perceives technological changes to be rapid	Generic application technologies (e.g., word processing, spreadsheet, presentation)	Heide and Weiss (1995) Weiss and Heide (1993)	✓	✓	✓	✓	✓
Intrusive features	Presenteeism	Degree to which technologies enable individuals to be reachable	Communication technologies (e.g., e-mail, voicemail)		✓	✓		✓	✓
	Anonymity	Degree to which exact use of technology could be identifiable	Collaborative technologies (e.g., IM (instant messaging), videoconferencing, teleconferencing)	Pinsonneault and Heppel (1993)	✓	✓		✓	✓

†Using ratings for technology characteristics (e.g., usefulness) across the *list of ICTs* considered by individuals in this study (see Appendix A), this column presents the technology that is rated the highest for each characteristic.

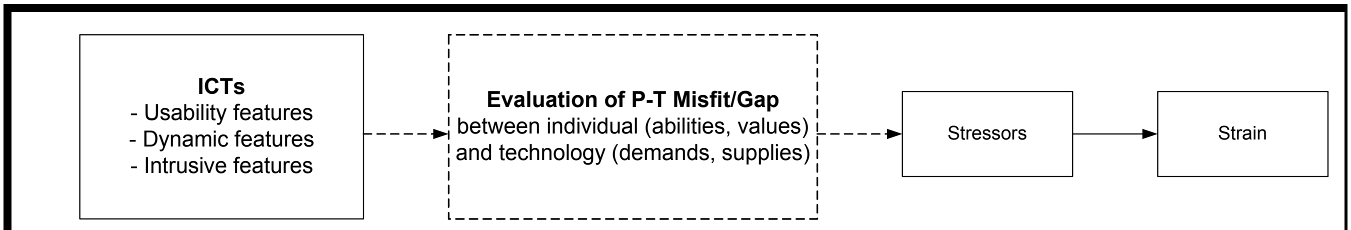

Figure 3. Impact of ICTs on Person–Technology Fit

Table 4. Linking the ICT Characteristics to Stressors Using P-E Logic

ICT Characteristics	P-T Dimension†	Key Influences on P-T Gap		Effect on P-T Fit	P-T Gap Reflected as Stressors				
		Person	**Technology Environment**		**Work Overload**	**Role Ambiguity**	**Invasion of Privacy**	**Work–Home Conflict**	**Job Insecurity**
Usefulness	A-D	• Individual's perceived ability to do more		Fit	✓				
Complexity	A-D		• Increased effort demanded by ICT to deal with knowledge barriers	Misfit	✓				
Reliability (reversed)	A-D		• Increased effort demanded by ICT to offset reliability concerns	Misfit	✓				
Pace of Change	A-D		• ICT creates new learning demands	Misfit	✓				
		• Reduced individual ability due to uncertainty regarding management of work and learning demands	• ICT increases effort due to uncertainty regarding management of work and learning demands	Misfit		✓			
		• Individual abilities could become obsolete		Misfit					✓
Presenteeism	A-D		ICT creates additional demands regarding availability and respon-siveness leading to						
			• increases in work demands	Misfit	✓				
			• increases in demands due to interruptions	Misfit		✓			
		• Individual inability to disengage from work demands		Misfit				✓	
	S-V	• Individual preference not to work from home	• ICT creates expec-tations to work from home	Misfit				✓	
		• Individual's need for certainty	• Interruptions create uncertainty	Misfit		✓			
		• Individual's value of privacy	• ICT creates constant connectivity	Misfit			✓		
Anonymity (reversed)	S-V	• Individual's value of pirvacy	• ICTs enable monitoring	Misfit			✓		

†A-D refers to abilities–demand and S-V refers to supplies–values dimensions.

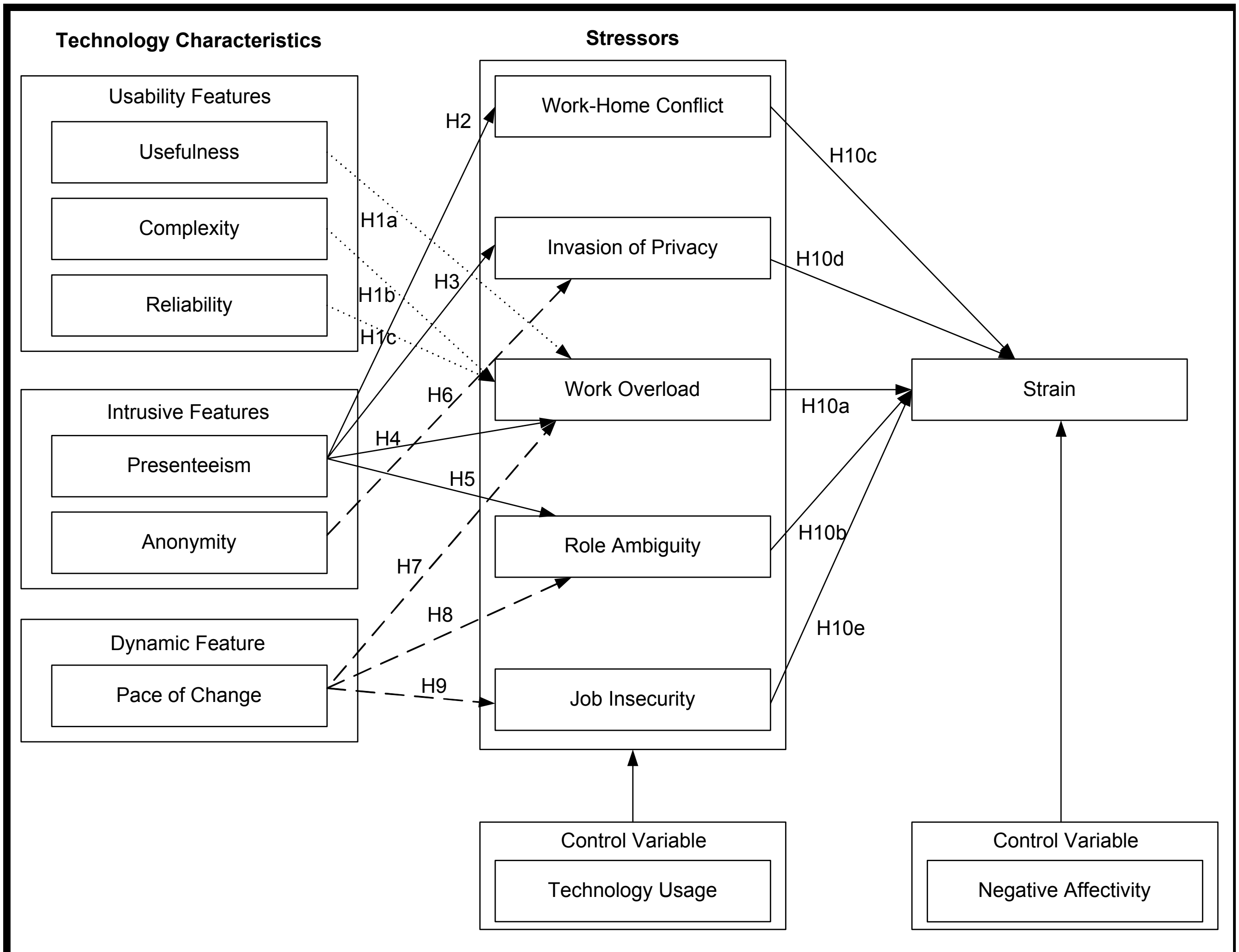

Figure 4. Proposed Research Model

Usability Characteristics

We propose that the three characteristics that typically enable ICT adoption and use—usefulness, complexity, and reliability—affect work overload. Our broad thesis is as follows. Given the premise of voluntary adoption of ICTs, these characteristics have been shown to predict adoption and use. However, in the present technological context at the work place, there usually is not a choice for adoption and use of ICTs (Weil and Rosen 1997) due to the requirements of the job and/or due to the implicit norms at work (e.g., e-mail technologies, use of mobile devices, etc.) (Brown et al. 2002; Mazmanian et al. 2006). This implies that individuals might have low perceptions of usability features (which would predict non-adoption) but still have to adopt and use technologies due to constraints in the work environment, thereby triggering perceptions of having to work harder (Aborg and Billing 2003). In terms of the P-T model, characteristics that enhance usage will increase ability without increasing demand by a corresponding amount, resulting in a lower perceived gap. Also, evidence suggests that use of technologies based on compliance, rather than on voluntary adoption, creates values–supplies conflict that can be stressful (Sami and Pangannaiah 2006).

As individuals find technologies useful, it enhances individuals' abilities to do things faster or be more productive, thereby reducing the perception of work overload. Similarly, perceptions of individuals' abilities are lowered if individuals do not see the technology as useful in completing the communication (Straub and Karahanna 1998) and believe that the work demands could be addressed in a better way (Weil and Rosen 1997). Further, the involuntary adoption of not so useful technology (as perceived) enhances the conflict between peoples' values and environment supplies (Sami and Pangannaiah 2006). Therefore, it is hypothesized that

H1a: Individual perception of technology usefulness will be negatively related to perceived work overload.

As ICTs become more complex, users may become frustrated with the number of features, as well as how to use the features. For example, some users are dissatisfied with the growing complexity of mobile devices (CNN 2006b).[9] These perceptions of high complexity represent an effort (knowledge) barrier and require individuals to expend more effort (resulting in an enhanced evaluation of the P-T gap). As individuals' perceive the use of technology to be difficult, any work demands placed by the use of that technology are perceived to be challenging. While it could be argued that complex technologies might enhance ability, thereby reducing the gap, we purport that most individuals like their technologies to be simple, a premise on which Apple®'s technologies such as the iPod® and Mac® are built. Increasing perceptions of technological complexity by itself will simply increase the burden and the consequent misfit between abilities and demands. We therefore propose

H1b: Individual perception of technology complexity will be positively related to perceived work overload.

Reliability, that is the dependability and consistency of a system, is recognized as a factor in IS success models (DeLone and McLean 1992, 2003; Jiang et al. 2002). However, present day ICTs are complex and are not inherently reliable (Butler and Gray 2006). Commonly discussed reliability problems are software errors, quality problems, and failures (Abdel-Hamid 1999; Austin 2001; Ba et al. 2001). Users interacting with unreliable ICTs are reported to be frustrated and strained (Aborg and Billing 2003; CNN 2006b). We argue that the threat of unreliability increases the perceived workload. First, individuals may have to repeat tasks in light of breakdowns. Second, individuals could have increased workloads due to the fear of breakdowns. Therefore, it is not necessary that the actual technology is unreliable. However, if an individual perceives it to be unreliable, it causes increased workload as precautions must be taken against the threat of breakdown. Based on the above arguments it is hypothesized that

[9]As one market researcher asks regarding mobile devices, "Why is every user interface based on typing when typing is the worst thing individuals do on mobile devices?"

H1c: Individual perception of technology reliability will be negatively related to perceived work overload.

Intrusive Characteristics

Presenteeism

In the context of the present study, we define presenteeism as the degree to which the technology enables users to be reachable. The underlying premise of this concept is that different ICTs offer different degrees of connectivity. Evidence suggests that IT can contribute to burnout by enabling employees to be accessible to the office anytime and anywhere through laptops, e-mail, cell phones, etc. (McGee 1996). ICTs are also seen as a source of interruptions in human–computer literature, leading to reduced efficiencies and stress (McFarlane and Lotorella 2002). Further, ICTs enable increased communication flow among individuals and could lead to irresolution of work tasks. This kind of fragmentation of work tasks is seen as a source of frustration (Straub and Karahanna 1998). The concept of presenteeism is one of the most widely discussed factors in the practitioner and technostress literature (Davis 2002; Kakabadse et al. 2000; Ragu-Nathan et al. 2008; Tarafdar et al. 2007; Tu et al. 2005; Weil and Rosen 1997). We contend that the ability to be accessible induces strain through four stressors: work–home conflict, invasion of privacy, work overload, and role ambiguity.

Work–Home Conflict: Career-oriented individuals are increasingly augmenting the time spent at the office with work done at home, made possible by different ICT devices and applications. While constant connectivity via new technologies might have benefits for some, it also comes at the cost of blurring work-home boundaries (Mann and Holdsworth 2003). This has been shown to be a source of strain (Duxbury and Higgins 1991). Laptops, cell phones, broadband connections, and other ICT advances are blurring the boundaries of work–home by providing increased access to work and to individuals. In many cases, the prevalence of the "working from home" concept leads to an unspoken norm in which individuals are expected to work from home (Mazmanian et al. 2006; Middleton and Cukier 2006). In terms of P-T fit, as individuals are limited in their abilities (resources), these increased demands enhance the P-T gap. Further, individuals' values and preferences in terms of not working from home might not be fulfilled by the expectation to work from home. Therefore, it is hypothesized that

H2: Individual perception of technology presenteeism will be positively related to perceived work–home conflict.

Invasion of Privacy: Individuals are becoming increasingly concerned that their privacy could be invaded by computer technologies (Best et al. 2006). The problem is acerbated due to the present work pressures, which create an unspoken value that appreciates individuals who are constantly available. Even on vacation, ICTs make it possible, almost expected, for an individual to work (say) using a BlackBerry. However, BlackBerry's common pseudonym of "CrackBerrys" reflects individuals' over-reliance on them. The popular press suggests that this type of over-identification with ICTs could lead to diminished well-being in individuals. Individuals who are off-BlackBerrys have reported being more effective (CNN 2006a). To this end, some hotels are offering a service for locking up guests' BlackBerrys. This is intended to provide privacy and real time-off without digital leashes. To the extent that individuals value privacy, available technologies might not fulfill these expectations, leading to a P-T misfit. Therefore, we propose

H3: Individual perception of technology presenteeism will be positively related to perceived invasion of privacy.

Work Overload: Presenteeism could also manifest in perceptions of work overload. Arguably, advances in connectivity increase the speed of workflow and heighten expectations for productivity (Clark and Kalin 1996), leading to jobs that require individuals to work under time pressures and strict deadlines. However, the need to work under time pressure and meet deadlines is shown as a source of work overload (Cooper et al. 2001; Narayanan et al. 1999). Assumed availability and responsiveness around the clock created by ICTs increases demands on individuals in terms of expectations of faster turnaround times. In effect, these increasing demands due to technology presenteeism increase the P-T gap. Given the constraints on abilities (resources), the increase in demands leads to greater perceived workload.

H4: Individual perception of technology presenteeism will be positively related to perceived work overload.

Role Ambiguity: ICTs can also create a constant demand for attention (Davis 2002). It is common for individuals to leave their e-mail open, or create an alert on their mobile phone whenever a new e-mail is received. The need to respond to constant demands stimulated by presenteeism eventually takes "time away" from work. The demands placed by interruptions create ambiguity on which task or job to perform, thereby constraining individual abilities. Further, ICTs enable multitasking, which often adds a layer of decision making as to what task an individual should perform and in what order (Kakabadse et al. 2000). Although it could be argued that some individuals have the choice to be "disconnected," it may not always be possible. The acts of certain highly motivated individuals create unspoken norms (Davis 2002) for the whole group or organization (for example, in terms of responding to e-mails quickly), commonly referred to as "tragedy of commons." To the extent that individuals value certainty, presenteeism creates uncertainty on whether or what to do. Therefore, the constant connectivity supplied might not fulfill the individual's expectations, enhancing the P-T gap. It is hypothesized that

H5: Individual perception of technology presenteeism will be positively related to perceived role ambiguity.

Anonymity

Anonymity refers to the degree to which an individual perceives that the use of ICTs is not identifiable, or cannot be tracked. If the individual perceives that the use of ICTs can be monitored, it represents low anonymity. Individuals are apprehensive about the possibility of invasive monitoring by organizations (Best et al. 2006; Boyd 1997; George 1996). Doyle (1999) reports that many corporations are engaged in some kind of intrusive employee monitoring, including checking e-mail, telephone conversations, video recording, and recording of computer activity. Research in the area of computer performance monitoring (CPM) acknowledges that computer monitoring is stressful on employees (DeTienne 1993; Frey 1993; Jenero and Mapes-Riordan 1992; Parenti 2001; Smith et al. 1992). The ability of technology to identify people and their behavior enables monitoring—which, if done explicitly or implicitly, may be inconsistent with the individual's values (i.e., concerns over loss of privacy). Therefore, the anonymity characteristic of technology could lead to invasion of privacy by enhancing the P-T gap along the value–supply dimension. This is stated as

H6: Individual perception of technology anonymity will be negatively related to perceived invasion of privacy.

Dynamic Characteristics

Pace of Change

Pace of change refers to the degree to which an individual perceives the changes in his or her technological environment to be rapid. This is exemplified by either the changes to existing technologies, or the introduction of new technologies. Constant changes in ICTs create adaptation demands on individuals that could be new learning demands, or demands resulting from changes in functionality of ICTs (Korunka and

Vitouch 1999). It is argued that pace of change exacerbates work overload, role ambiguity, and job insecurity.

Work Overload and Role Ambiguity: Typically, introduction of new technologies is argued to be a contributing factor to increased levels of job insecurity (Johansson 1989; Korunka et al. 1995). However, Korunka et al. (1997) suggest that while the introduction of ICTs is important, continuous changes in ICTs are also important in understanding individuals' stress responses. Further, Arnetz (1997) argues that constant development of new software tools and rapidly changing technical and business environments result in high levels of stress. Empirical evidence suggests ICTs change faster than the ability of humans to adjust to the change (Pascarella 1997). In a similar vein, Vernon (1998) notes that the speed of technology change means people have to spend more than their usual hours to cope with innovation and work.

Employees are also pressured by the pace at which they have to adapt to new ICTs (Weil and Rosen 1997). Even as they get accustomed to one particular tool or program, they often have to keep up with a "better" tool or program that can "do more." This not only takes time to learn, but sometimes renders the skills of employees obsolete (Sami and Pangannaiah 2006). In addition to the demands of the job, constant changes place demands on individuals' attention to acquire new skills. This increased demand on their time increases the P-T gap. As individuals have limited cognitive resources, the increased demands due to pace of change in ICTs lead to increased workload. Therefore,

H7: Individual perception of technology pace of change will be positively related to perceived work overload.

In addition, there is uncertainty as to whether an individual should expend his or her resources to perform the task requirements at work or to acquire new skills. These competing demands between the job and learning new skills constrain individual abilities, thereby enhancing the P-T gap. Further, there is empirical support for the notion that individuals, when faced with learning technologies, experience feelings of ambiguity and competing demands, which lead to role ambiguity (Rangarajan et al. 2005). Therefore,

H8: Individual perception of technology pace of change will be positively related to perceived role ambiguity.

Job Insecurity: Previous research reports that job insecurity and technology perceptions are related (Vieitez et al. 2001). Studies on resistance to technological change have mainly identified fear of job loss as a source of resistance (Slem 1986). Individuals' concerns often relate to fears of becoming obsolete, or the requirement to learn new or higher skills (Korunka et al. 1996). Constant changes in ICTs and the vast number of options available render individual skills obsolete. Further, due to limited cognitive resources, individuals often feel left out of the latest developments. These increased demands due to pace of change of ICTs enhance the P-T gap leading to job insecurity. Therefore,

H9: Individual perception of technology pace of change will be positively related to perceived job insecurity.

Finally, the relationship between the identified stressors and strain is well established in the extensive stress literature (e.g., Burke and Cooper 2000; Cooper et al. 2001; Frone et al. 1992; Judge et al. 1994; Kinman and Jones 2005; O'Driscoll and Beehr 1994; O'Driscoll et al. 1992; Smith et al. 1992). Therefore, we hypothesize

H10a-e: Perceived stressors (work overload, role ambiguity, work–home conflict, invasion of privacy, and job insecurity) are positively related to perceived strain.

Control Variables

Negative affectivity and technology usage are identified as two control variables. Negative affectivity (NA) is a dispositional factor that reflects a tendency to experience negative emotional states and low self-esteem (Watson and Clark 1984). It is argued that individuals high in NA are inclined to experience higher levels of strain and other negative outcomes in work settings (Semmer 1996). Consequently, using self-reports of stressors and strains are advised to control for NA (Burke et al. 1993). Therefore, NA is statistically controlled in this study.

Also, since the effects of technologies are a function of when the technologies are used and the degree to which they are used, it is necessary to control for technology usage. It is expected that regular users of ICTs would have more opportunities to deal with effects of technologies as compared to occasional users. Therefore, technology usage could provide an alternate explanation to the stress experienced by individuals due to ICTs. Accordingly, technology usage is used as a control variable. Past research on technology usage has almost exclusively used self-report measures of technology usage (Speier and Venkatesh 2002). Usage is typically measured by single item questionnaires measuring actual daily use; for instance, the amount of time spent and frequency of use (Anakwe et al. 2000; Igbaria 1992; Kim et al. 2005; Lee 1986).

Research Method

The aim of the present work is to develop a model for technostress and understand the relationship between technology characteristics and relevant stressors. Since the emphasis is on explaining the variance and in developing causal relationships, the field study methodology is used and statistical analysis is performed using structural equation modeling.

Before we discuss the data collection section, we highlight the approach we used for the measurement of P-T fit. In the broader P-E fit literature, the fit is measured in two ways: indirect (also referred to as atomistic or reductionist) approach and a direct (also referred to as perceived, molar, or gestalt) approach (Dawda and Martin 2001; Edwards et al. 2006; Kristof-Brown et al. 2005). Both of these approaches are widely used in the literature (Kristof-Brown et al. 2005). In the indirect approach, both the individual and environment measures are obtained and these measures are combined statistically to yield a measure of (mis)fit (for example, through a difference score). In the direct approach, the individuals directly report on the (mis)fit. Note that these are different measurement approaches to the same concept and it is argued that these approaches yield the same results if respondents are accurate in their self-assessment. In this study, we used the direct approach for the following reasons. In an argument to support direct measures over the problematic difference scores used in indirect approaches, Johns (1981, p. 459) points out that

> If the respondents can describe existing organizational conditions and preferred organizational conditions, they can surely report directly whatever it is we think we measure when we calculate the difference between these descriptions.

Further, another advantage of direct assessment is that it allows individuals to apply their own weighing scheme when comparing P and E components. Also, Edwards et al. (2006) indicate that direct fit captures more than a systematic combination of person and environment components. In their meta-analysis, Kristof-Brown et al. (2005) suggest that indirect approaches may be appropriate when the precision of fit relationships is required and direct approaches are useful when investigating the consequences of fit. Therefore, in this study, we used direct assessments of misfit.

Data Collection

The target population for this study is not limited to any particular occupation. Most of the previous stress works have used samples from a particular profession or occupation (nurses, machine operators, etc.) (Fox et al. 1993; Rangarajan et al. 2005). In IS-stress studies, the sample frame consisted of IS/IT professionals (Chilton et al. 2005; Moore 2000; Weiss 1983). To truly understand the impact of ICTs on individuals in work settings, key attributes of the population should be individuals who work full-time and use ICTs. Therefore, the population selected for this study is the working adult population who are business users of ICTs.

The required sample was obtained using the services of a market research firm called Zoomerang. This is a leading market research company that provides, among other services, respondents from their panel who participate in various research studies. Over 2 million members exist in this panel and these members are profiled over 500 attributes (http://www.zoomerang.com). Zoomerang (2009) reports that the profile of their panel is representative of the U.S. population. This kind of data collection could provide greater control (based on the attributes selected), and there is precedent for using this data collection method in academic research[10] (e.g., Rogers and Bazerman 2008; Thau et al. 2009).

To satisfy sample frame requirements, screening questions were developed. These questions were "Do you work full time?" and "Do you use any of these technologies?"[11] If the respondents answered affirmatively, they were able to participate in the study. In this way, it was possible to target the desired population frame of full-time working business users of ICTs. In addition, we also captured overall usage (in hours). The respondents were asked to indicate the average number of work hours (i.e., hours they spend doing work related activities) and the average number of hours spent using ICTs.

Measures

Wherever possible, existing scales were adapted for the context of this study. For newly developed scales (e.g., presenteeism), careful consideration was given to the content validity of the measures. This was achieved by ensuring that the items capture the meaning of the constructs. We have adapted Moore's (2000) work exhaustion construct for strain measure in this paper. It should be noted that several assess-

[10]More details about Zoomerang, its applicability, and the sample selection process are explained in Appendix A.

[11]A list of common ICTs was provided. More details are provided in Appendix A.

ments of strain are used in the literature, including widely used concepts of exhaustion, turnover intentions, and job satisfaction (Cooper et al. 2001; Kahn and Byosiere 1992, Vaananen et al. 2004; Van Katwyk et al. 2000). There is an indication that exhaustion precedes other measures, such as turnover intentions (de Croon et al. 2004). In addition, there is support for using the exhaustion concept in related MIS literature (Ahuja et al. 2007; Moore 2000). We further believe that exhaustion captures the impact of technostress better than job satisfaction. Appendix B provides the scales used in the study and their sources.

In using the direct assessment of misfit, our items reflect the meaning of perceived P-T fit (i.e., stressors). Understanding the meaning of perceived fit has been a challenge (Edwards et al. 2006). Consider the items for work overload (a representative item is "I feel busy or rushed due to ICTs"). Perceived fit on this dimension explicitly refers to the effect of demands arising from technology and implicitly refers to individual abilities to meet those demands. High scores mean that perceived work demands exceed individual abilities and, thus, the work overload stressor is high or perceived fit on this dimension is low. Low scores mean that perceived work demands do not exceed abilities and, thus, the work overload stressor is low or perceived fit on this dimension is high. Consider the items for role ambiguity (e.g., "I am unsure what to prioritize: dealing with ICT problems or my work activities"). Perceived fit on this dimension explicitly refers to the individual's inability to meet the competing demands created by technology. High scores mean that perceived (competing) demands exceed individual abilities and, also, that situations created by technology are implicitly not consistent with the individual's preference for certainty. Thus, the role ambiguity stressor is high or perceived fit on this dimension is low. Similar reasoning implies that low role ambiguity scores mean that perceived fit on this dimension is high. For work–home conflict (e.g., "Using ICTs blurs boundaries between my job and my home life"), perceived fit refers to the individual's inability to meet the conflicting demands created by technology between the work and home spheres. High scores mean that perceived (conflicting) demands exceed individual abilities and, also, that situations created by technology regarding present work expectations are implicitly not consistent with the individual's preferences. Thus, the work–home conflict stressor is high or perceived fit on this dimension is low. For invasion of privacy (e.g., "I feel uncomfortable that my use of ICTs can be easily monitored"), the item compares the present technological environment to the individual's value for privacy. High scores mean that technologies create situations that are implicitly not consistent with the individual's preferences and, thus, the invasion of privacy stressor is high or perceived fit on this dimension is low. Finally, for job insecurity (e.g., "I am worried that new ICTs may pose a threat to my job"), perceived fit on this dimension infers that the individual's abilities could be obsolete due to constant changes in technologies. High scores mean that perceived demands due to constant changes in technologies exceed individual abilities and, thus, the job insecurity stressor is high or perceived fit on this dimension is low.

Results

Once a satisfactory questionnaire was developed, it was subjected to further refinement. Eight individuals involved in academic research and well versed in field study methodology participated in carefully analyzing the wording of the items in the questionnaire. Further, detailed interviews were conducted with three full-time working individuals assessing the readability of the survey items. Each interview lasted an average of 25 minutes. Minor changes were made to the wording and design of the questionnaire. Overall, the feedback received suggested that the questionnaire was well developed.

Sample Characteristics

A total of 1,411 individuals accessed the survey developed on Zoomerang. Of these, 692 made it through the screening questions related to sample frame requirements described previously. The survey was designed such that all of the items on the questionnaire had to be completed; therefore, there was no missing data. However, preliminary analysis revealed that some of the data was invalid. Specifically, there were cases in which "total number of ICT hours" were greater than "total number of work hours" and in some cases invalid characters were entered for open-ended questions. These cases were deleted. Also, initial screening for outliers was conducted, resulting in a final sample size of 661. The demographic characteristics of the sample are presented in Table 5.

Almost an equal split is achieved with respect to gender (48 percent female). Approximately 33 percent of the respondents were single, 58 percent were married, and most respondents had graduated college. Respondents represented a wide variety of industries; the top six industries represented are education, healthcare, government, finance, retail, and manufacturing. On an average, the respondents were 49 years old, had 27.3 years of work experience, and 14.5 years of experience using various ICTs. Given the average years of work

Table 5. Demographics	
Gender	48–52% split, 48% female
Age	Mean 49 years; median 52 years
ICT Usage	Mean 22.25 hours; median 20 hours
Work Experience	Mean 27.3 years; median 29 years
ICT Experience	Mean 14.5 years; median 15 years
Education	High School 7.2% Some College 17% Graduated College (2 and 4 year) 42.3% Graduate School 11% Postgraduate 22.3%
Marital Status	Single 33.4% Married 58.1% Other 8.4%
Industry	Education 16.9% Healthcare/medical/pharmaceutical 10.6% Government/military 9.3% Finance/banking/insurance 7.1% Retail/wholesale 6% Manufacturing 5.7%

experience and average years of experience with ICTs, the average age estimate seems reasonable. Previous stress studies in IS research have reported similar demographics (Moore 2000). Appendix C provides details on the reliability and validity analysis and common method bias is dealt with in Appendix D.

Measurement and Structural Models

The measurement model consisted of all the items loading on their respective factors and also on a single method factor simultaneously. In the measurement model, all of the constructs were freely correlated (except the method factor). The fit indices shown in Table 6 suggest that the data fits the model well. The values were above the suggested cutoffs of 0.90 for CFI, 0.10 for SRMR, and 0.10 for RMSEA (Kline 2005). Further, in the structural model all the factor co-variances were removed and structural paths were added, reflecting the proposed hypotheses. This model also shows appropriate fit with the data, illustrated in Table 6. The results from the structural analysis shown in Figure 5 were used for hypotheses testing, which is discussed next. The results of control variables are discussed in Appendix E.

The path coefficients from the structural model are used to test the hypotheses. For each hypothesis, standardized coefficients and their significance levels are tabulated in Table 7.

Discussion

The research goal of this study was to investigate the role of technology characteristics in inducing stress in individuals. The developed research model argued that technology characteristics induce stress by enhancing the misfits between the individual's abilities—environment's demands and between the individual's supplies—environment's values. The misfits are characterized in terms of stressors due to ICTs. That is, technology characteristics are proposed as antecedents to stressors, which in turn are predictors of strain (due to ICTs).

The presentation of findings from these results is organized as follows. First, the relations between stressors and strain are discussed, followed by relations between technology characteristics and stressors.

Predictors of Strain

The results of the present study suggest that technostress is real, and deserves attention in the present technology-oriented environment. The results indicate that approximately 35 percent[12] of the variance in strain is explained by proposed stressors (i.e., work overload, role ambiguity, work–home conflict,

[12]Excluding the impact of the control variable.

Table 6. Fit Statistics

Model	SRMR	CFI	RMSEA	Chi-Square
Measurement Model	0.036	0.986	0.027	1089 with 744 df
Structural Model	0.072	0.917	0.037	1986 with 1044 df

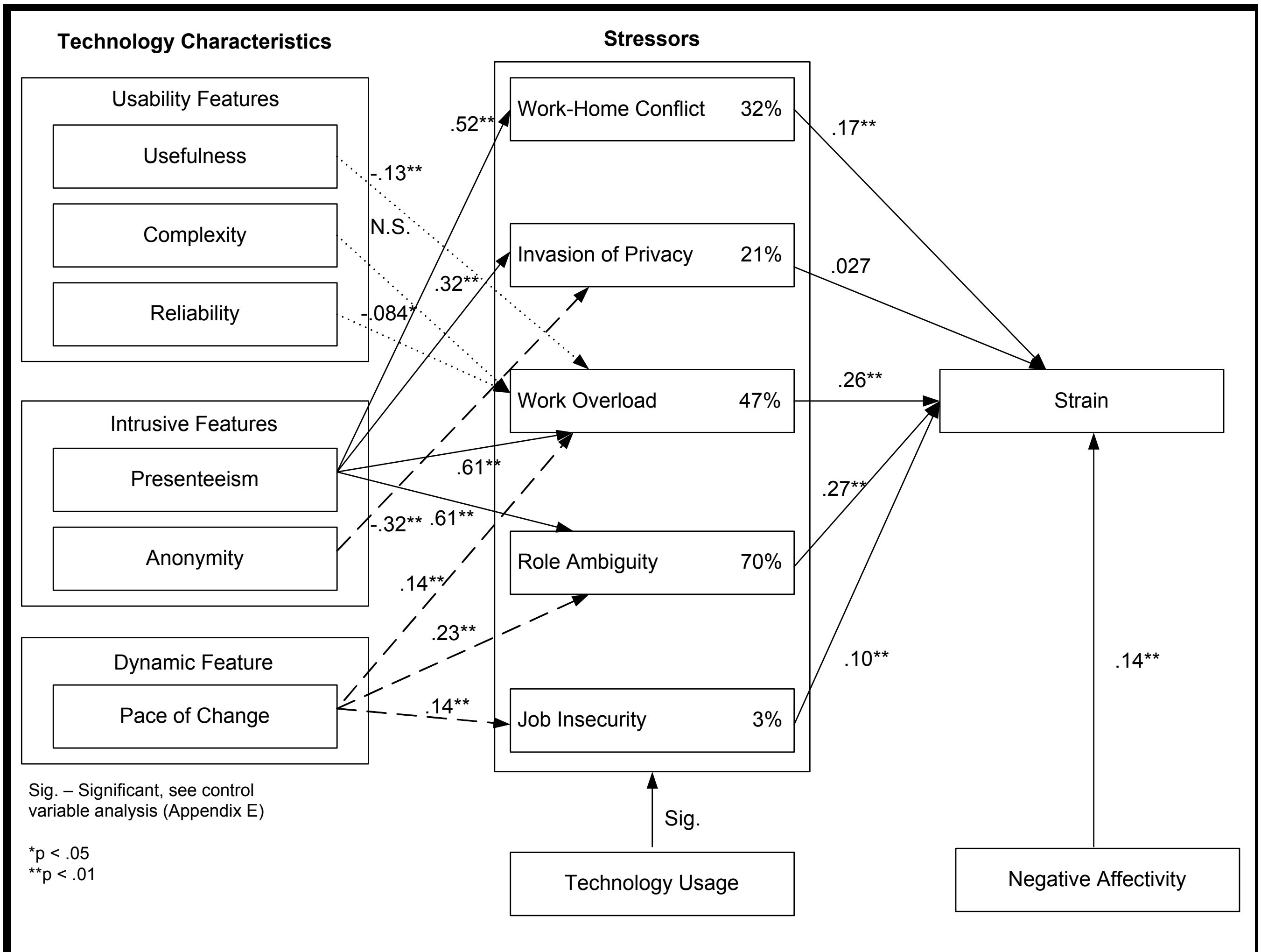

Figure 5. Structural Model with Results

Table 7. Summary of the Proposed Hypotheses

	Hypotheses	Supported?
H1a:	Individual perception of technology usefulness will be negatively related to perceived work overload ($\beta = -0.13$, $p < 0.01$)	Yes
H1b:	Individual perception of technology complexity will be positively related to perceived work overload ($\beta = 0.07$, $p > 0.05$)	No
H1c:	Individual perception of technology reliability will be negatively related to perceived work overload ($\beta = -0.08$, $p < 0.05$)	Yes
H2:	Individual perception of technology presenteeism will be positively related to perceived work– home conflict ($\beta = 0.52$, $p < 0.01$)	Yes
H3:	Individual perception of technology presenteeism will be positively related to perceived invasion of privacy ($\beta = 0.32$, $p < 0.01$)	Yes
H4:	Individual perception of technology presenteeism will be positively related to perceived work overload ($\beta = 0.61$, $p < 0.01$)	Yes
H5:	Individual perception of technology presenteeism will be positively related to perceived role ambiguity ($\beta = 0.61$, $p < 0.01$)	Yes
H6:	Individual perception of technology anonymity will be negatively related to perceived invasion of privacy ($\beta = -0.32$, $p < 0.01$)	Yes
H7:	Individual perception of technology pace of change will be positively related to perceived work overload ($\beta = 0.14$, $p < 0.01$)	Yes
H8:	Individual perception of technology pace of change will be positively related to perceived role ambiguity ($\beta = 0.23$, $p < 0.01$)	Yes
H9:	Individual perception of technology pace of change will be positively related to perceived job insecurity ($\beta = 0.14$, $p < 0.01$)	Yes
H10:	Stressors (work overload, role ambiguity, work–home conflict, invasion of privacy, and job insecurity) are positively related to strain.	Partial†
H10a:	Individual's perception of work overload is positively related to perceptions of strain ($\beta = 0.26$, $p < 0.01$)	Yes
H10b:	Individual's perception of role ambiguity is positively related to perceptions of strain ($\beta = 0.27$, $p < 0.01$)	Yes
H10c:	Individual's perception of work–home conflict is positively related to perceptions of strain ($\beta = 0.17$, $p < 0.01$)	Yes
H10d:	Individual's perception of invasion of privacy is positively related to perceptions of strain ($\beta = 0.027$, $p > 0.05$)	No
H10e:	Individuals' perception of job insecurity is positively related to perceptions of strain ($\beta = 0.10$, $p < 0.01$)	Yes

†We indicate partial support because four out of five hypotheses in H10 are supported.

job insecurity and invasion of privacy offered in H10). The strongest contributors to strain in this sample were role ambiguity and work overload, which exhibited similar path coefficients. The next strongest predictor was work-home conflict, followed by job insecurity. Contrary to expectations, invasion of privacy did not significantly relate to strain.

The emergence of role ambiguity (due to ICTs) as a strong predictor of strain implies that individuals have a hard time managing the burden placed by constant interruptions and conflicting demands. The results provide indirect empirical support for the argument that in an information economy, attention is a scarce resource (Davenport and Beck 2001). Therefore, the ability of individuals to focus their attention and deal with constant interruptions and conflicting demands appears to be a major challenge. Consistent with other stress studies in different contexts, work overload (due to ICTs) also emerged as a significant predictor of strain. ICTs appear to be creating situations where work demands exceed individuals' abilities (Tu et al. 2005).

The blurring of boundaries between work and family life also had a significant impact on strain. Since individuals' resources (in terms of time, energy, etc.) are limited, greater conflicts between work and family spheres offer higher levels of strain. Similarly, the positive relationship between job insecurity and strain indicates that misfit exists between individual and environment with respect to perceptions of job security. Finally, there was lack of support for the contention that invasion of privacy was a predictor for strain, suggesting that in the present environment individuals might be tolerant and accept invasion of privacy as an offshoot of advances in ICTs. For example, Best et al. (2006) indicate that monitoring workplace communications (like e-mail and web use) has become widespread and, therefore, individuals have become more tolerant of monitoring. Also, there is some support to indicate that individuals accept the intrusive nature of technologies due to existing norms or due to productivity expectations (Allen and Shoard 2005; Mazmanian et al. 2006).

Technology Characteristics as Antecedents to Stressors

The proposed model argued that ICTs enhance the misfit between person and technology environment, thereby creating a component of stressors that are attributed to ICTs. The findings between technology characteristics and stressors are discussed below.

Predictors of Work Overload

Technology characteristics from usability features (usefulness, complexity, and reliability), dynamic feature (pace of change), and intrusive features (presenteeism) were proposed as antecedents to work overload (H1, H4, and H7). The findings suggest that 42.6 percent of variance in work overload is explained by these factors.

The results indicate that the constant connectivity provided by ICTs increases the workload by enhancing the speed of work flow and expectations of productivity (Clark and Kalin 1996). Further, the dynamic nature of ICTs also increased perceived work overload when technologies change beyond an individual's ability to cope. On the other hand, improving the characteristics of usability features reduced the perceived work overload. Specifically, as individuals find ICTs useful and reliable it leads to lower levels of work overload.

Contrary to expectations, complexity of ICTs did not significantly increase work overload in the present sample. There could be two reasons for this finding. First, it is possible that since the ICTs considered here are generic, rather than work-specific, complexity of the technology itself was limited and consequently was not significant. Second, business users' level of techno-savvy was systemically high, which might have weakened any relationship between complexity and the overload stressor.

Predictors of Role Ambiguity

Perceptions of technology presenteeism and pace of change were proposed as antecedents to role ambiguity (H5 and H8). Both proposed links were significant and these two factors explained 66 percent of the variance in role ambiguity. These results indicate that constant connectivity enables interruptions at work and constant changes in ICTs create situations in which conflicting demands exist (i.e., normal work demands versus new learning demands).

Predictors of Work–Home Conflict

Twenty-eight percent of the variance in work–home conflict was explained by technology presenteeism (H2). These findings support the arguments that constant connectivity provided by ICTs encroaches on the personal space of individuals. In the present networked world, the results indicate that it is a challenge to maintain a work–life balance.

Predictors of Job Insecurity

Technology pace of change is proposed as a predictor to job insecurity (H9). As expected, this link was significant and contributed to 2 percent of explained variance in job insecurity. These findings support the arguments that constant changes in ICTs makes individuals apprehensive about their skill set or about the possibility of being replaced.

Predictors of Invasion of Privacy

Technology presenteeism and anonymity were proposed as predictors of invasion of privacy (H3 and H6). Both the proposed links were significant and these two factors explained 20 percent of the variance in invasion of privacy. These findings suggest that individuals are wary about the possibility that their actions with ICTs be traced or monitored. Also, the constant connectivity enabled by ICTs seems to instill the feeling that individuals are always at work.

Implications

Subsequent subsections discuss the implications of this study and are organized into contributions to technostress and IS research, and implications for practice. Key contributions and implications are summarized in Table 8 and are further discussed in the following sections.

Contributions to Technostress and IS Research

This study extends past stress research by showing that predictors of strain due to ICTs (stressors like work overload, work–home conflict, role ambiguity, etc.) have their own determinants (usefulness, presenteeism, anonymity, etc.). Below, we discuss the contributions of this work to the limited technostress literature in particular and to IS research in general.

Additions to Existing Knowledge

This study explicitly identifies technology characteristics and their relation to stressors, thereby significantly extending the present understanding on technostress (Ragu-Nathan et al. 2008; Tarafdar et al. 2007). Rather than treat technology as a black box that somehow manifests strain in individuals, we can now delineate different characteristics of technology and their varying impact on stressors. The proposed model also provides researchers with the ability to evaluate the root causes of technostress. Rather than just asking "What are the dominant stressors?" it is also important to ask "What are the determinants of these stressors?" and "Can we influence the manifestation of stress through these technologies?" In future, new technologies could be evaluated on their characteristics and their potential stressful impacts could be identified even before these technologies are fully utilized. The results of the present study are also more generalizable, as the sample used is not idiosyncratic to any particular organization. The present work also moves beyond the occupation-focused stress studies in IS literature (Ahuja et al. 2007; Moore 2000). The developed model is not constrained to any particular occupation; in fact, it is developed to understand the impacts of ICTs across different occupations in an organization.

The IT Artifact Box

In their review of IS research, Orlikowski and Iacono (2001) identified that most IS studies fall into the nominal category (i.e., IT artifacts are treated nominally or don't exist). One of the examples they provide in this category is studies on IT/IS professionals, similar to the dominant perspective of stress in IS research. They advocate that IS researchers should place specific emphasis on the IT artifact. Our work moves beyond the nominal treatment of the IT artifact in previous IS stress research. Our conceptualization of IT artifact is based on individuals' perceptions about ICTs. Orlikowski and Iacono categorize this as the "proxy" view, especially "technology as perception." They also suggest that the phenomenon investigated and questions addressed in a research study should help articulate the IT artifact. Our investigation of technostress using the P-T framework places emphasis on individual's perceptions about technologies in work settings. Therefore, the proxy view of the IT artifact seems appropriate.

Further, Orlikowski and Iacono urge researchers to move beyond taking IT artifacts for granted or assuming them to be unproblematic. They point to a need for studies that explore unintended consequences of technologies. Specifically, these authors argue for studies that focus on (1) "psychological…aspects of an array of evolving technologies and the ways in which they are…used" (p. 130) and (2) "how people engage with various technological artifacts in the course of working" (p. 132). Our conceptualization of technostress contributes to the above points. It sheds light on people's engagement with technologies for work tasks and their unintended consequences as measured by psychological outcomes (i.e., strain).

ICT Adjustments

The proposed model also informs us on the individual's adjustments and impacts of ICTs (Nelson 1990; Weber 2004). Nelson (1990) argues that many studies on individual adjustment to technologies treat technologies as undifferentiated and do not consider specific features. For example, she suggests that "a computer itself may not be a source of stress; rather, delayed response times may be stressful to the worker" (p. 87). She has called for future research to consider specific features of technologies in understanding how individuals adjust to technologies. The present study contributes by providing direction on this issue, identifying characteristics (e.g., reliability) that could be subject to adjustment in order to gain beneficial effects.

Specific Technologies

It should also be noted that in the proposed model, technology characteristics are generic and not constrained to any particu-

Table 8. Key Contributions and Implications

Contributions and Implications	For Research	• Makes technology characteristics explicit in explaining technostress • Present conceptualization moves beyond the dominant stress research on IT professionals and provides model based on theoretical arguments that is not restricted to any profession • Opens the IT artifact box with a proxy view of ICTs and explores their unintended consequences • Does not treat technologies as undifferentiated and examines outcomes specifically linked to their attributes • Proposed framework could be applied to a specific technology in specific context (e.g., BlackBerry use by sales personnel) or to build a typology for technologies • Support for intrusive features and dynamic feature provides encouragement to move beyond the usability features stream of IS research • Sensitizes researcher to an alternative mediating path through stressors between IT and outcomes that has implications for strain and productivity
	For Practice	• Proposed model could be used as a diagnostic tool to assess stressful impacts of technologies and their causes in organizations • Provides guidance on the interventions that could reduce costs of stressed individuals to organizations • Reinforces alternate rationale for usefulness and reliability of technologies • Implies development of effective time and attention management strategies/policies to relieve ICT pressure • Need to manage expectations on the job (e.g., about availability and responsiveness) to reduce stressors like work–home conflict

lar technology. For instance, Weber (2004) called for more research to better understand e-mail in organizational context, including understanding the stressful effects of e-mail. The conceptualization presented in this inquiry could be applied to e-mail, not only to address whether use of e-mail systems is stressful, but also to shed light on what aspects of e-mail systems are stressful. This provides a complementary perspective to the current status on research in e-mail (Gupta et al. 2006), which addresses issues related to the design of e-mail systems, how to manage e-mail, and how often to check e-mail.

New Directions

This research also sets new directions for future work on technostress. The present conceptualization of technology characteristics as antecedents to stressors, which act as predictors of strain, is much more consistent with the broader stress literature and has more explanatory power as to how different aspects of technologies could be stressful. Findings from the present study also imply that, at least in technostress-related phenomena, individuals' perceptions of usability features seem less critical than intrusive features, and to some extent dynamic feature characteristics of ICTs. This implies that researchers should go beyond the traditional usability features to gain better understanding of the consequences of technology use.

Methodologically the study contributes in terms of its treatment to reduce the threat of common method bias. First, it created psychological separation between criterion and predictor variables. Second, the threat of common method variance is *actively controlled* by modeling a latent method factor. Further, the operationalization of constructs like presenteeism could be useful for future technostress and stress work. The strong support for technology presenteeism as a predictor for various stressors implies that more attention needs to be paid to this concept as ICTs become pervasive.

Future Research

The support for our model is encouraging for future research.[13] It can be argued that because of the generic nature of our study, results provided here are conservative. Stronger results could be expected in studies that focus on exploring the stressful effects of one specific technology relevant from

[13]The limitations of this study, which also work as potential research opportunities, are discussed in Appendix F.

a technology or organizational context. For example, future research might explore more specific questions such as, is the use of a BlackBerry stressful? Or, is the use of a BlackBerry by a sales professional stressful?

Another potential research avenue is to consider developing a taxonomy or typology for ICTs. This will be necessary if the focus of a research question is on the stressful impacts of one group of technologies, for example, mobile technologies. However, there is no known categorization of ICTs that effectively organizes different technologies in a mutually exclusive and collectively exhaustive fashion. The previous categorizations have mainly focused on differentiating technologies along (1) storage, (2) communication, and (3) processing dimensions. However, with the integration of data and communication technologies, there is a need for developing a better taxonomy or typology.

Once such a categorization of technologies is developed, the present conceptualization could be used to profile various technologies. Specifically, the strength of the relationships between technology characteristics–stressors–strain could be tested for various technologies. In this way, it is possible to identify which particular technology characteristic is most stressful for any technology and whether it significantly differs when compared to other technologies. Such pinpoint analysis could be used for developing appropriate policies to deal with the stressful impacts of technologies.

In an increasingly networked environment, the intrusive nature of technology is gaining importance. Technology is seen as a source of interruptions and the resulting issue of fragmented attention and its management have become important research areas (McFarlane and Lotorella 2002). Interruptions are seen as disruptive, resulting in such issues as resumption lag, reduced efficiencies, etc. (Altman and Tafton 2004; Gillie and Broadbent 1989). Given the importance of the intrusive nature of technologies, the understanding obtained from the present model could contribute to future research. For example, Speier et al. (2003) call for better understanding on the interruptive nature of technology and their impact on performance. They note that, "given the role of information technology as a possible 'generator' of interruptions, we also need to understand more fully the effect of technologies on decision-making performance" (p. 790). Specifically, they call on future research to understand the impacts of e-mail and instant messaging technologies on the decision maker's performance. The present work contributes by providing evidence that technologies are interruptive and provides guidance in which stressful impacts of various technologies could be evaluated. Although performance is not directly studied, the present model could be extended to accommodate performance aspect. Therefore, this study provides one mechanism in which interruptive aspects of technology could be studied.

As technology gets more and more embedded into the individual's work processes, closer attention could be paid to how the varying degree of the material (IT) and social aspects become entangled in the work environment (Orlikowski and Scott 2008). Such an analysis would complement the results of the present study in explaining why certain technologies can lessen or enhance stressful situations. It can also provide much deeper understanding about how individuals interact and cope with technologies.

Another interesting avenue to consider is the potential episodic nature of stressful events when dealing with ICTs. For example, a computer might hang or crash (i.e., reliability issues). If these issues happen repeatedly, it can be reflected in a perceived reliability measure. However, if it is an isolated event and did not reach a level of consistency, then perhaps our current approach (i.e., field study) would miss it. In these situations, an event-based approach that looks at episodic stress would be valuable.

Addressing technostress by using commensurate scales would be a useful study[14] to delve explicitly into the mediating effects of the P-T model. In commensurate scales, one scale measures the individual dimension and another measures the environment dimension. Statistical fit measures then could be obtained between these two measures. This indirect approach would complement the direct approach used in the present study as it is suggested that these two approaches might be capturing different aspects of fit. The indirect approach could also benefit from the polynomial regression method, which could be used to investigate the exact form of fit relationships (Edwards et al. 2006; Kristof-Brown et al. 2005). Notably, development of commensurate scales would require specific information about the individual's work environment. Therefore, for a particular work group in a specific organization, this type of approach can be used to see impacts of technologies.

Previous research has related strain to turnover intentions, productivity, organizational commitment and job satisfaction (Ahuja et al. 2007; Jex 1998; Moore 2000; Ragu-Nathan et al. 2008; Tarafdar et al. 2007). Specifically, it is argued that strained individuals, particularly those indicating exhaustion, are less committed, have greater turnover intentions, and have lower job satisfaction. Given the importance of human capital

[14]We than an anonymous reviewer for this suggestion.

to present-day organizations, future research could extend the present study to see the direct and indirect effect of technology characteristics on these outcomes.

In addition to the psychological manifestations of strain considered in this study, there are other unintended effects of using ICTs. For example, one of the widely known physiological concerns of using ICTs is that of carpal tunnel syndrome. Recent discussions on BlackBerry thumbs also point out potential problems of repetitive strain disorders. Exploring the unintended consequences of ICT use to physiological symptoms is another fruitful research avenue. Finally, the present study positioned in a broader nomological context as presented in Figure 6 gives insights into future research directions.

Implications for Practice

The present work also offers some managerial implications that could be used to ameliorate some of the unintended effects of ICT use. These are described below.

The Validity of Technostress

The results from this study provide support for the phenomenon of technostress. Most of IS research is concentrated on understanding what technology can do *for* you. However, given the significance of technostress, and stress in general, it is important that organizations be aware of what technologies can do *to* you. Therefore, organizations could use the model developed in this study as a tool to assess the levels of technostress. Since the model is not technology specific, it can be customized to fit the needs of different departments or divisions. By focusing on a technology or a set of technologies, each organizational group could get better insight into the dominant causes of technostress. Understanding the specific causes would be a first step in developing effective management programs to deal with technostress.

The Bottom-Line Impacts of Technostress

Why should managers care about the results of this study? Based on research linking stress to performance (Cooper et al. 1996; Sutherland and Cooper 1990; Tennant 2001), we would urge management to focus on two aspects that directly impact an organization's bottom line. First, stressed individuals are shown to have lower productivity and have higher propensity to quit. Given the importance of human capital, human resource managers should focus on reducing levels of technostress. Second, stress has been related to many health ailments, and considering the prohibitive cost to companies that pay for health benefits, managers have an incentive to proactively reduce stress levels. Although this might involve organizations spending money up front, the overall benefits realized will, potentially, outweigh costs involved.

The Importance of Usability Characteristics of Technologies

Previous research on adoption and diffusion of technologies has underscored the importance of developing technologies that demonstrate characteristics of usefulness and reliability. The present work suggests that not only are these characteristics important from an adoption point of view, but they can also help reduce the stressful impacts of technologies. Results indicate that by improving the perceptions of usefulness and reliability (either by developing better systems or by communicating these characteristics better) the work overload perceptions of individuals could be reduced. As is shown before, work overload is one of the dominant causes of technostress.

Time and Attention Management Strategies

The finding that role ambiguity is a dominant stressor, and that technology presenteeism is one of the key stressful characteristics of technology, calls for certain managerial interventions. It was suggested that the interruptions and uncertainty created by technologies were a cause for role ambiguity. Accordingly, management should train employees with respect to effective time management strategies to deal with these situations. Also, managers should develop policies that encourage organizational members to keep a part of the work day exclusively for themselves (free of interruptions) to do real work. For example, individuals could communicate that they will not be replying to e-mail or taking phone calls during a specified period and ask other organizational members to cooperate. Also, some explicit policies or arrangements could be made so that employees do not abuse the constant connectivity provided by technologies. For example, if a policy such as "e-mails could be responded to in a day's time" is maintained and encouraged by the group, it would relieve the pressure on individuals to constantly check and respond to e-mails. Further, managers should promote individuals with strong work–home boundaries as role models. Although ever-present employees might seem productive at first glance, the results of this study show that this type of individual's well-being could suffer in the long-term, thereby increasing overall costs to the organization.

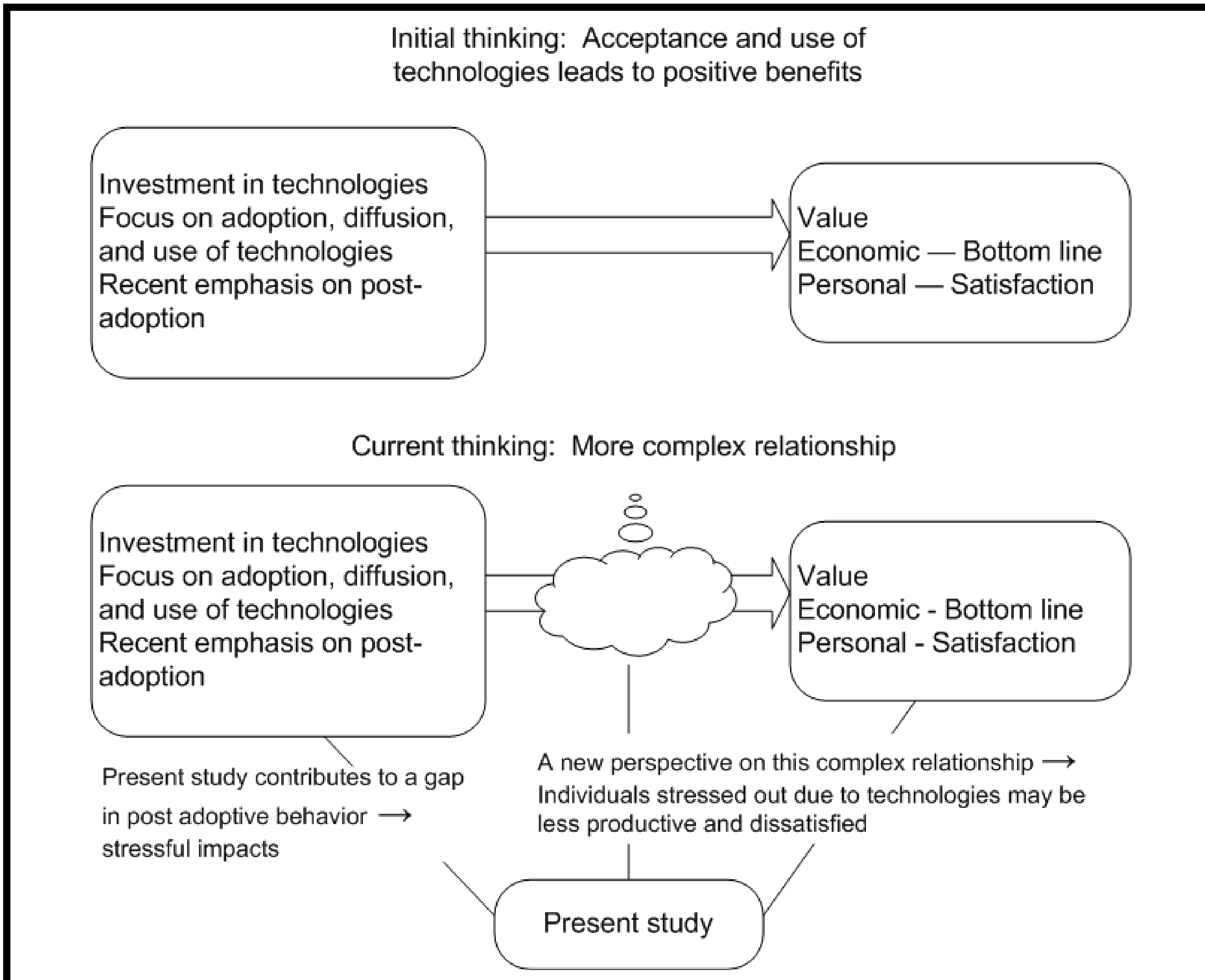

Figure 6. Present Study in Broader Literature

Manage Expectations While on the Job

Related to the above point, managers can implement explicit work norms (at least as relates to ICTs) and thereby manage job expectations relating to an individual. This might alleviate some of the concerns of work overload and work–home conflict due to ICTs. For example, managing expectations about after-hour availability (i.e., after work day, weekend, vacations, etc.) can reduce work–home conflict situations. Similarly, by managing expectations, individuals might perceive lower demands on their resources, leading to lower perceptions of work overload.

Conclusion

This study represents an initial step in integrating the stress and IS literature for explaining the phenomenon of technostress. Although previous research in IS literature has looked at issues related to stress in IS professionals, the issue of stress *due to* ICTs has not received much attention. Overall, the present study identifies how specific technology characteristics predict stressors that, in turn, predict individual strain due to ICTs. We can now address some of the questions raised in introducing this study. For example, a manager may be doing more harm than good by expecting after-hour availability or instant responsiveness from his/her group, and may find that enforcing strong work–home boundaries is beneficial. Given the pervasiveness of ICTs in organizational and individual life, it is imperative that the impacts of ICTs are understood. To this end, we are hopeful that the conceptualization presented in this study serves as a catalyst for more research on ICTs and stress.

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RESEARCH ARTICLE

TECHNOSTRESS: TECHNOLOGICAL ANTECEDENTS AND IMPLICATIONS

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Appendix A

Survey Details

Details about Zoomerang

Zoomerang has over 2 million registered individuals (referred to as Zoompanel). Zoomerang profiles its panelists on over 500 attributes and provides incentives to the panelists for their participation in surveys. Zoomerang (2009) reports that their panelists represent the U.S. census. In fact, they claim that their random selection of panelists would provide a nationally representative sample as opposed to a random convenience sample.

Individuals that participate in Zoomerang's research have double opted into the panel to provide opinions. Double opt-in implies that panelists sign up and then are given a chance to back out of the panel (making sure that they really DO want to participate). For their opinions and time, the panelists are provided with incentive points for each survey that they complete. This is not dissimilar to the incentives often given to complete an instrument in traditional academic mail surveys where mailings are made to a directory (sample frame) of participants.

We report that data collected using Zoompanel provides greater control because "inclusion criterion" could be developed in terms of screening questions to ensure sample frame requirements are met. For example, if a study's sample requirements are IT managers working in nonprofit organizations in the northeast, it could be achieved by developing appropriate screening questions. Based on the information stored on each panelist, Zoomerang sends invitations to a nationally representative random sample, and the screening questions developed by researchers specific to their studies ensure that the final sample obtained is random and meets the sample frame requirements.

Since the present research studies the impact of ICTs on individuals, the sample frame is not constrained to any particular occupation. To truly understand the impact of ICTs on individuals in work settings, some key attributes of the population are desired (i.e., individuals should be working full-time, they should use ICTs). Therefore, the population selected for this study is the working adult population who are business users of ICTs.

So we developed two inclusion criteria:

- Do you work full time?
- Do you use any of these technologies?

Existing academic studies that used Zoompanel data used a similar approach to obtain their sample; that is, Zoomerang sends an e-mail to their panelists with a link to the questionnaire and the respondents are filtered based on sample frame requirements to obtain required sample (see Wallenstein et al. 2008; Yang et al. 2008).

We would also like to engender confidence in the use of online panel data for academic research. Braunsberger et al. (2007) report that data obtained from online panels is more reliable than that obtained from telephone surveys, engendering confidence in use of online panel data. In addition, Zoomerang is not the only online panel source which has been used in academic research (e.g., Piccolo and Colquitt 2006[1]). Further, and more importantly, we would like to engender confidence in the use of Zoompanel as a data source.

In academic research, data from Zoompanel is used in the fields of organizational behavior (Rogers and Bazerman 2008; Thau et al. 2009), marketing (Du et al. 2007; Wonder et al. 2008), psychology (Basil et al. 2009), medical sciences (Becker et al. 2007; Wallenstein et al. 2008; Yang et al. 2008), food service (Hicks et al. 2008), hospitality management (Lynn 2009; Shang et al. 2010). Although we used Zoompanel as a data source, we had complete control over all other aspects of research methodology (e.g., we provided the text to be included in the email invitation, developed the survey hosted at http://www.zoomerang.com, etc.).

Information on ICTs

The following information is provided at the beginning of the survey to clarify what is meant by ICTs.

- **Please note** that ICTs involve a collection of information, processing, storage, network, and communication technologies.

  ICTs are **NOT** shop-floor manufacturing technologies that are used to automate manufacturing processes. A list of **ICTs** is provided below.

An example of a representative stem we used is "Considering the use of information and communication technologies (ICTs) for your work-related tasks, indicate the degree to which you agree to the following." Note that we emphasized use of ICTs for work-related tasks (i.e., not for personal use).

The list of ICTs used in this study to screen the sample is provided below. Further, once the respondents were actually taking the survey, a hyperlink to the term *ICTs* is provided on each survey page.

List of ICTs

- Mobile technologies (e.g., Cell phone, Pager, BlackBerry®, Laptop, PDA (personal digital assistant))
- Network technologies (e.g., Internet, Intranet, VPN)
- Communication technologies (e.g., e-mail, voicemail)
- Enterprise and Database technologies (e.g., PeopleSoft®, SAP®, Oracle® applications)
- Generic application technologies (e.g., Word Processing, Spreadsheet, Presentation)
- Collaborative technologies (e.g., IM (instant messaging), VideoConferencing, Teleconferencing)
- Other work specific technologies

[1]For a list of other studies, go to "The Study Response Project" at http://studyresponse.syr.edu/studyresponse/techreports.htm.

Appendix B

Items and Loadings

Construct	Items	Factor Loadings	Reliability (alpha) α
Work Overload (Moore 2000)	ICTs create many more requests, problems, or complaints in my job than I would otherwise experience.	0.73	0.88
	I feel busy or rushed due to ICTs.	0.88	
	I feel pressured due to ICTs.	0.87	
Work Home Conflict (Kreiner 2006; Netemeyer et al. 1996)	Using ICTs blurs boundaries between my job and my home life.	0.83	0.93
	Using ICTs for work-related responsibilities creates conflicts with my home responsibilities.	0.90	
	I do not get everything done at home because I find myself completing job-related work due to ICTs.	0.92	
Invasion of Privacy (Alge 2001; Eddy et al. 1999)	I feel uncomfortable that my use of ICTs can be easily monitored.	0.85	0.94
	I feel my privacy can be compromised because my activities using ICTs can be traced.	0.92	
	I feel my employer could violate my privacy by tracking my activities using ICTs.	0.91	
	I feel that my use of ICTs makes it easier to invade my privacy.	0.84	
Role Ambiguity (Moore 2000)	I am unsure whether I have to deal with ICT problems or with my work activities.	0.86	0.93
	I am unsure what to prioritize: dealing with ICT problems or my work activities.	0.86	
	I can NOT allocate time properly for my work activities because my time spent on ICTs-activities varies.	0.90	
	Time spent resolving ICT problems takes time away from fulfilling my work responsibilities.	0.82	
Strain (Moore 2000)	I feel drained from activities that require me to use ICTs.	0.91	0.97
	I feel tired from my ICT activities.	0.97	
	Working all day with ICTs is a strain for me.	0.93	
	I feel burned out from my ICT activities.	0.92	
Usefulness (Moore and Benbasat 1991)	Use of ICTs enables me to accomplish tasks more quickly.[†]	0.87	0.94
	Use of ICTs improves the quality of my work.	0.89	
	Use of ICTs makes it easier to do my job.	0.93	
	Use of ICTs enhances my effectiveness on the job.	0.92	
Complexity[‡] (Moore and Benbasat 1991)	Learning to use ICTs is easy for me.	0.77	0.90
	ICTs are easy to use.	0.86	
	It is easy to get results that I desire from ICTs.	0.94	
Reliability (DeLone and McLean 1992, 2003; Jiang et al. 2002)	The features provided by ICTs are dependable.	0.85	0.86
	The capabilities provided by ICTs are reliable.	0.90	
	ICTs behave in a highly consistent way.	0.86	
Presenteeism	The use of ICTs enables others to have access to me.	0.90	0.97
	ICTs make me accessible to others.	0.94	
	The use of ICTs enables me to be in touch with others.	0.97	
	ICTs enable me to access others.	0.95	

Construct	Items	Factor Loadings	Reliability (alpha) α
Anonymity (Pinsonneault and Hippel 1997)	It is easy for me to hide how I use ICTs. I can remain anonymous when using ICTs. It is easy for me to hide my ICT usage. It is difficult for others to identify my use of ICTs.	0.92 0.90 0.97 0.88	0.95
Pace of Change (Heide and Weiss 1995; Weiss and Heide 1993)	I feel that there are frequent changes in the features of ICTs. I feel that characteristics of ICTs change frequently. I feel that the capabilities of ICTs change often. I feel that the way ICTs work changes often.	0.88 0.93 0.87 0.80	0.94
Job Insecurity (Ashford 1989)	ICTs will advance to an extent where my present job can be performed by a less skilled individual. I am worried that new ICTs may pose a threat to my job. I believe that ICTs make it easier for other people to perform my work activities.	0.89 0.80 0.71	0.84
Negative Affectivity (Agho et al. 1992)	I often find myself worrying about something. My feelings are hurt rather easily. I suffer from nervousness. My mood often goes up and down. I often lose sleep over my worries.	0.72 0.72 0.82 0.78 0.71	0.86

†Petter et al. (2007) argue that typical usefulness constructs have both reflective and formative items. For example, this item could be argued as being formative with respect to the next item. This is still a gray area as most of the items are interchangeable.
‡Note that the measures are reverse coded (i.e., higher scores on these items implies lower complexity).

Technology usage was captured by a single item measuring the time spent using ICTs.

Appendix C

Reliability and Validity Analysis

The means and standard deviations for each of the constructs are shown in Table C1. Next, all of the items were loaded onto their respective latent constructs. The factor loadings and reliabilities of the constructs used in this study are also shown in Table C1.

Further, the correlations among the constructs and the average variance explained for each construct is shown in Table C2. Convergent validity and reliability of constructs used in this study are reflected through the measures of Cronbach's alpha, factor loadings, and average variance extracted (AVE). Results from confirmatory factor analysis, tabulated in Table C1, indicate that the reliabilities for all the constructs exceed the recommended cutoff of 0.70. The reliabilities of constructs in the present study are similar to those reported by Ahuja et al. (2007), whose work used constructs that are similar in nature to the present work. Further, all of the factor loadings are above the recommended value of 0.70 and the AVE for each construct is above 0.50, indicating that the latent factors can explain at least 50 percent of the measured variance among items (Fornell and Larker 1981). Discriminant validity among constructs is exhibited if the square root of average variance extracted (AVE) for each construct is greater than all interconstruct correlations (Chin 1998). As shown in correlations Table C2, the results indicate that all interconstruct correlations are less than the square root of AVE, indicating discriminant validity among constructs. Two additional analyses, including pair-wise comparisons of relevant constructs, also indicated that constructs exhibited discriminant validity.

Table C1. Factor Loadings and Reliabilities

Construct	Anchor Points	Mean	Standard Deviation	No. of Items	Confirmatory Factor Loadings Range	Reliability (alpha) α
Work Overload	1–Strongly Disagree 7–Strongly Agree	3.54	1.57	3	0.73-0.88	0.88
Work Home Conflict	1–Strongly Disagree 7–Strongly Agree	3.10	1.67	3	0.83-0.92	0.93
Invasion of Privacy	1–Strongly Disagree 7–Strongly Agree	4.14	1.74	4	0.84-0.92	0.94
Role Ambiguity	1–Strongly Disagree 7–Strongly Agree	3.19	1.47	4	0.82-0.90	0.93
Strain	1–Never 7–Daily	2.89	1.61	4	0.91-0.97	0.97
Usefulness	1–Strongly Disagree 7–Strongly Agree	5.35	1.21	4	0.87-0.93	0.94
Complexity	1–Strongly Disagree 7–Strongly Agree	5.10	1.25	3	0.77-0.94	0.90
Reliability	1–Strongly Disagree 7–Strongly Agree	4.58	1.26	3	0.85-0.90	0.86
Presenteeism	1–Strongly Disagree 7–Strongly Agree	5.69	1.07	4	0.90-0.97	0.97
Anonymity	1–Strongly Disagree 7–Strongly Agree	2.48	1.34	4	0.88-0.97	0.95
Pace of Change	1–Strongly Disagree 7–Strongly Agree	4.81	1.18	4	0.80-0.93	0.94
Job Insecurity	1–Strongly Disagree 7–Strongly Agree	3.12	1.52	3	0.71-0.89	0.84
Negative Affectivity	1–Strongly Disagree 7–Strongly Agree	3.34	1.63	5	0.71-0.82	0.86

Table C2. Correlations Among Constructs

Construct	wo	whc	inp	ra	s	pu	cm	rel	prs	ano	pc	ji	na
Work Overload–wo	**0.70**												
Work–Home Conflict–whc	0.54	**0.79**											
Invasion of Privacy–inp	0.30	0.24	**0.77**										
Role Ambiguity–ra	0.68	0.58	0.45	**0.74**									
Strain–s	0.58	0.51	0.31	0.59	**0.87**								
Usefulness–pu	-0.22	-0.08	-0.02	-0.08	-0.08	**0.82**							
Complexity–cm	-0.16	-0.16	-0.23	-0.16	-0.10	0.36	**0.74**						
Reliability–rel	-0.21	-0.11	-0.25	-0.19	-0.11	0.20	0.40	**0.76**					
Presenteeism–prs	0.19	0.12	0.13	0.14	0.21	-0.12	-0.07	0.01	**0.89**				
Anonymity–ano	-0.14	0.02	-0.32	-0.08	-0.11	0.12	0.18	0.31	-0.24	**0.85**			
Pace of Change–pc	0.20	0.14	0.16	0.25	0.25	-0.11	-0.08	-0.17	0.15	-0.18	**0.76**		
Job Insecurity–ji	0.13	0.20	0.20	0.19	0.21	0.18	0.08	0.24	0.04	0.08	0.17	**0.65**	
Negative Affectivity–na	0.21	0.18	0.25	0.23	0.30	0.03	-0.10	-0.09	-0.01	-0.10	0.14	0.17	**0.56**

Diagonal elements represent average variance extracted (AVE). For n = 661, correlations above 0.09 and 0.11 are significant at 5 percent and 1 percent respectively.

Appendix D

Common Methods Bias Analysis

Perceptual or subjective measures are used to effectively capture differences in individual responses to the same situations, rather than use objective measures (Cooper et al. 2001; Jex and Bheer 1991; Perrewe and Zellars 1999). However, common method bias could be a potential problem with subjective measures. In a critical review of common method bias in behavioral research, Podsakoff et al. (2003) provide recommendations to alleviate it. Specifically, they suggest that researchers

(1) use procedural remedies during questionnaire design, and
(2) use statistical controls

In this study, we have incorporated the above suggestions in the following way. For procedural remedies, we have

- Psychologically separated the measurements of criterion and predictor variables. This was achieved by providing a cover story between the criterion and predictor measurement phases (Table D1).
- Assured respondents' anonymity and that there is no right or wrong answer.
- Paid close attention to the items to avoid the use of ambiguous or unfamiliar terms, vague concepts, and "double-barreled" questions.
- Used different scale endpoints and formats for predictor and criterion variables, wherever possible.

Statistically, method variance is assessed by using Harman's single factor test and by modeling a single latent method factor. Harman's single factor test suggests that if a single factor explains significant covariance among variables, then it implies the presence of common method bias. The commonly accepted standard for *significant covariance* explained to be considered a potential problem is at least 25 percent. The results of this test did not yield a single dominant factor. The largest variance explained by a single factor in unrotated factor solution and in rotated factor solution is 21 percent and 9 percent, respectively. These results suggest that method bias might not pose a severe threat. However, it should be noted that Harman's test is only a diagnostic test and it does not actually control for method bias. Therefore, based on recommendations by Podsakoff et al. (2003) and recent IS articles (Ahuja et al. 2007; Liang et al. 2007), the unmeasured methods latent factor was explicitly modeled in this study.

In this approach, items are allowed to load on their proposed constructs and also on a latent common methods variance factor. The structural model is then tested for significance of parameters both with (Model B) and without (Model A) the latent methods factor. Model B makes intuitive sense because the same method was used to measure all of the variables. Modeling a latent method factor significantly improves the fit of the model if common method bias accounts for most of the covariance observed in the variables. The results of this analysis are summarized in Table D2.

Table D1. Procedural Remedies for Method Bias

Separation Introduced Through the Following Statements	Comments
Did you know? The Zip Code 12345 is assigned to Schenectady, New York.	Introduced between measures of stressors and strain
If you were wondering, zip code 54321 does not exist.	Introduced between measures of strain and technology characteristics
Did you know? Identical twins do not have identical fingerprints.	Introduced between measures of technology characteristics because the measures had similar anchor points
You are more than half-way through the survey...*Thank You* for your patience as we research this important issue. You have almost finished 90% of the survey...Thank You for helping in this non-profit research. Last two pages...Thank YOU!! for helping us better understand the implications of technologies.	These statements are distributed in the survey to motivate the respondents and also to provide separation

Table D2. Method Bias Test

Model	Chi-Square	CFI	RMSEA	Comment
Model A: All items load on respective factors.	1250 with 784 df	0.981	0.030	Significant method bias exists if Model B fits significantly better than Model A. Results indicate that ΔCFI is less than 0.01 indicating lack of method bias.
Model B: All items load on respective factors and also on a method factor.	1089 with 744 df	0.986	0.027	

While comparing the fit indices between Models A and B, it should be noted that chi-square differences are sensitive to sample size. Therefore, in addition to the chi-square difference test, researchers have suggested to test for differences in comparative fit indices (CFI) (Byrne 2006; Cheung and Rensvold 2002; Little 1997) where the difference in CFI should be less than 0.05 (Little 1997) or according to Cheung and Rensvold (2002) less than 0.01. Although the difference in chi-square itself is significant, it should be noted that the ratio of chi-square difference per single degree of freedom is less than 3. Further, these results are similar to those reported by Ahuja et al. (2007) and within the recommendations of Hu and Bentler (1999). Additional evidence was obtained by comparing the differences in CFI. The results indicate that CFI of 0.005 is less than the recommended values of 0.05 (Little 1997) or 0.01 (Cheung and Rensvold 2002). These results further provide support that common method bias was not a serious validity threat to this study.

Appendix E

Control Variable Analyses

In the proposed research model, it was argued that stressors due to ICTs (i.e., work overload, role ambiguity, work–home conflict, invasion of privacy, and job insecurity) should be controlled for technology usage, and strain due to ICTs should be controlled for the dispositional variable negative affectivity. The results support this argument. The results for control variables are shown below.

Control Variable Relationship	Standardized Coefficient (β)
For Technology Use and	
Work Overload	.21*
Role Ambiguity	.19*
Work–Home Conflict	.21*
Invasion of Privacy	.09**
Job Insecurity	.11*
For Negative Affectivity and	
Strain	.14*

*Significant at 1% **Significant at 5%

The links between technology usage and stressors are all significant (β's ranging from 0.09 to 0.21, all significant at 5 percent at least). The results indicate that as individuals become more dependent on technologies (i.e., increasing technology usage), they experience higher levels of stressors. It could also be interpreted that, as technology use increases, there are greater instances in which ICTs could enhance the stressors. Also, the link between negative affectivity and strain is significant at the 1 percent level with a standardized coefficient of 0.14. This implies that individuals' experience of strain could be explained by their tendency to evaluate situations more negatively. In other words, with all things constant, individuals who experience higher levels of negative affectivity will report higher levels of strain.

Appendix F

Limitations

Some of the limitations in this study come from the inherent conflict that exists between undertaking a study that is generalizable versus a study that is very specific (for example, with respect to either technologies, or occupations). One of the main limitations of this study is the aggregated and undifferentiated treatment given to the individual's technology use. Individuals responded to the technology characteristics (like usefulness, complexity, reliability, presenteeism, etc.) by aggregating their perceptions across the various ICTs they use. Consequently, an individual might have varying perceptions of usefulness with respect to the use of a mobile phone versus the use of a laptop. However, only one measure of usefulness is collected concerning their overall technology profile. Therefore, there is a lack of clarity on what this usefulness captures. Does it capture the average, or does any one technology from the profile of technologies influence the measure significantly? Although the overall measure we used cannot capture this detail, this approach was deemed an appropriate compromise to administering the research model for each technology. Further, the profile of technologies provided for respondents to evaluate the technology characteristics could be a limitation in itself. This is because there isn't an easy way to categorize the present ICTs into a mutually exclusive and collectively exhaustive manner.

The present study also didn't control for the diversity of technology use. It is possible that individuals who use 10 different technologies for a total of 10 hours could have varied stressful manifestations compared to individuals who use one technology for 10 hours. Just dealing with numerous technologies could be a source of stress. Further, although we believe that critical technology characteristics are considered, the proposed characteristics might not be exhaustive. In addition, as technologies change and new technologies are introduced, it is possible that new characteristics that are not considered might gain significance.

Another fundamental question[2] that might arise is with respect to the constructs of technology characteristics. Since the main contribution of the paper is identifying the technology component in the technostress phenomenon, it is critical to think about how far or how close to technology the technological characteristics (in this study usefulness, reliability, etc.) are. Although at first glance the current technology characteristics might not seem to reflect the technology component, it is useful to think of technology characteristics existing at different levels of abstraction. The lowest level of abstraction could represent the physical reality of the technology and a higher level of abstraction could represent a more logical description of technology (like our technology characteristics). It is our contention that individuals' use of technologies evokes responses at the logical rather than at the physical level of abstraction.

Also, the respondents consisted of individuals from different occupations and organizations. There might be certain organizational and occupational differences that could be investigated. Accordingly, the differentiating effects of profession and occupation could be taken into account in future research. Further, the present study utilized data collected at one point in time. Therefore, it cannot confirm the causality of the links proposed in the model. However, as pointed out by Moore (2000), some of the links between stressors and strain were previously tested longitudinally, and provide some support for the causality proposed in this study. Future research should consider using longitudinal designs. Another factor that might limit discovery of causal links is the field study methodology itself and its ability to isolate ICT effects. Although care was taken to keep the respondents within the bounds of the context (i.e., their use of ICTs), isolating strain or stressors due to ICTs to the exclusion of other causes might not be fully realized. Use of experimental settings might alleviate these concerns.

Finally, this study does not explicitly examine the coping mechanisms that moderate an individual's reactions to stressful situations. Stress research suggests that dispositional (e.g., personality variables, self-efficacy) and contextual variables (e.g., social support) increase the individual's coping ability and thereby act as buffer mechanisms against stressful situations (Cooper et al., 2001). The model developed in the present research paper could be enhanced to include moderating effects of coping. Considering the context of this study, specific constructs that are studied as moderators could be technological self-efficacy and technical support.

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[2]We thank a reviewer and the associate editor for these arguments. As noted in the paper, the term *technology characteristics* actually refers to the *assessment of technology characteristics*.

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