Technostress and Technology Induced State Anxiety: Scale Development and Implications

Research in Progress Paper

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Abstract

Technostress is a new concept in IS research which is still in the nascent stages of theoretical development. Despite a growing number of studies that examine the concept, a direct measure of technostress has yet to be developed, or distinguished from related affective states such as computer anxiety. In this paper, a unidimensional measure of technostress is created and validated in two different samples. In addition, based on the Affective Response Model, the technology induced state anxiety (TISA) concept is introduced and conceptually distinguished from computer anxiety and technostress. The discriminant validity of TISA, technostress and computer anxiety is tested in a nomological net of antecedents and objective technology performance outcomes using an experimental design. PLS modeling is used to test several hypotheses, the majority of which are supported. This work forms an important step in further understanding negative affective concepts related to technology use, and devising intervention mechanisms.

Keywords: End-user computing, Performance, Technology use, Technostress, Technology Induced State Anxiety, Affect, Scale Development

Introduction

As our personal and professional lives become increasingly dependent on various technologies, the study of unintended negative consequences of technology use has become essential. One area of consequence is the negative affective states and dispositions that are formed due to technology. Technostress is a relatively new concept in the information systems (IS) discipline that broadly refers to the negative impact that technology use, directly or indirectly, has on attitudes, thoughts, behaviors and even the biological systems of individuals. The concept is still within an early stage of development in the IS literature (Tarafdar et al. 2013) and can benefit from a stronger theoretical core to inform future research (Riedl 2012). Further, given accumulating evidence of the negative influence of technostress-creators on productivity, end-user satisfaction (Tarafdar et al. 2013), feelings of strain (Ayyagari et al. 2011), and even sales performance (Tarafdar et al. 2015), a more nuanced understanding of this concept is theoretically and practically relevant. Such efforts will aid the development of interventions targeted specifically at reducing technostress and other negative affective reactions to technology use.

To advance research on technostress, outstanding issues pertaining to the conceptual distinctiveness of the construct and the way it is measured are worthy of attention. For instance, no known studies have measured both *computer anxiety*, an older affective IS concept, and technostress or theoretically distinguished them from each other. Also, technostress is yet to be measured directly using a unidimensional reflective measurement scale which is needed to better assess construct validity. A recently published theoretical framework for the study of affect-related concepts in IS, the Affective Response Model (ARM; Zhang 2013), is well suited to both tasks.

Therefore, this paper seeks to extend the current understanding of technostress by (1) theoretically and empirically distinguishing technostress from computer anxiety using ARM, (2) developing and validating a reflective measure of technostress, and (3) introducing a distinct state-level, negative affective variable in line with recommendations of ARM. Using a laboratory experiment where objective task complexity was manipulated, new measures are validated and the three focal constructs are shown to have distinct, but related effects in the presence of antecedents and objective performance outcomes. This work represents a first step in a research program to explicate the theoretical underpinnings of important affective concepts in IS with a view to devising human-based, technology-based and organization-based approaches for reducing technostress.

Theoretical Foundation & Hypotheses

Technostress can be broadly described as any stress response directly or indirectly attributable to potential or actual technology use. Paraphrasing the two most common definitions of the concept, it is a negative impact on attitudes, thoughts, behaviors, or body physiology caused by an inability to cope with computer technologies in an effective manner (Brod 1984; Rosen and Weil 1997). A lack of consensus exists on a more specific definition due to the different conceptualizations of the root word 'stress', including (1) an internal state caused by technology or technology use (i.e. "strain"); (2) an external event/characteristic associated with technology (or "stressor"); or (3) an experience that arises from a transaction between a person and technology (Mason 1975). IS research on technostress reflects this ambiguity with some papers measuring technostress as stressors (or technostress-creators) (Tarafdar et al. 2007), others measuring it as an internal state of strain (Ayyagari et al. 2011), and using neurobiological measures such as cortisol levels (Galluch et al. 2015; Riedl et al. 2012). Further, the concept is yet to be effectively distinguished from existing negative, affective concepts such as computer anxiety and technophobia.

A review of the IS literature on technostress suggests some consistency in how it is studied, generally with reference to regular use of a specific technology or group of technologies by business users. Studies of technostress report asking participants to focus their attention on technology used frequently in their daily work lives while responding to surveys (Ayyagari et al. 2011; Tarafdar et al. 2007). Further, existing research takes the view that features of technology can cause technostress. Features such as presenteeism, usefulness, pace of change, anonymity, complexity and uncertainty/reliability have been found to influence perceptions of stress, measured as work-home conflict, role ambiguity, privacy invasion, overload and job insecurity (Ayyagari et al. 2011; Ragu-Nathan et al. 2008; Tarafdar et al. 2010, 2011). Another agreement in the literature is that technostress gives rise to relevant behavioral and psychological outcomes, such as decreased user satisfaction, and productivity (Ragu-Nathan et al. 2008; Tarafdar et al. 2007, 2010). In addition, the mediating and moderating effects of other factors such as self-efficacy, technology dependence, and organizational support have been shown (Ragu-Nathan et al. 2008; Shu et al. 2011).

While prior research has measured technostress-creators (Tarafdar et al. 2007; Tarafdar et al. 2015) and technostress outcomes (Ayyagari et al. 2011), a visible gap in the study of technostress is the absence of a reflective measurement scale to directly capture the concept. We consider this a limitation for two reasons. First, reflective measurement items are critical for validating formative constructs, especially in the presence of other antecedents, in order to limit interpretational confounding (MacKenzie et al. 2011; Gregor and Klein 2014). Constructs are not inherently formative or reflective in nature (MacKenzie et al. 2011), and alternate conceptualizations of technostress are needed. Existing measures of technostress creators are formative and multidimensional, and while we agree that "formative modelling is more consistent with the conceptual nature of technostress creators" (Fuglseth and Sørebø 2014, p. 161), a reflective, unidimensional and consistent representation of overall technostress complements the multidimensional measure of technostress creators that change with the specific context. Secondly, the existing technostress-creators scale is bound to organizational contexts, however, there is no reason to believe that technostress is not being experienced *@work, @home, and @play* (Rosen and Weil 1997). An important aspect of defining new constructs is specifying how stable the construct should be "over time, across situations, and across cases" (MacKenzie et al. 2011, p. 300). If future research on technostress should "reveal insights in particular contexts" (Tarafdar et al, 2015, p. 108), a complementary, unidimensional measurement scale that can be used consistently across these contexts is essential.

Technology Induced State Anxiety (TISA)

Given that technostress is considered an on-going perception directed towards a specific technology or group of technologies, research in this area can benefit from examining how induced states during episodes of technology use translate to enduring feelings of technostress. This process is explicitly addressed in ARM, based on recent theoretical consensus in psychology. Specifically, a reciprocal relationship exists between induced affective states and particular affective evaluations during a person's interaction with a specific technology (proposition 3 and proposition 4 in Zhang (2013)). This proposition is based on what is known about the causal relationship between affective states and affective evaluations, as well as the opposite relationship evidenced by models such as the prototypical emotional episode model (PEEM) (Russell 2003; Zhang 2013). Therefore, ARM justifies the need to propose the concept of technology induced state anxiety (TISA), a negative affective state which is related to, but distinct from enduring learned affective evaluations such as technostress. Such a concept may even connect more closely to the use of neurophysiological measures and other NeuroIS measures (Riedl 2012). While, computer anxiety (CA) has been treated as a state anxiety in IS and related research in the past, more recently, ARM holds that CA is most accurately treated as a temporally *unconstrained* learned affective evaluation towards using computers *in general* (Zhang 2013). The absence of any studies that empirically measure technostress or technostress-creators alongside CA, and CA alongside an explicitly declared state variable, present a gap in need of addressing. Details of how TISA, technostress and CA differ conceptually based on the categorization provided by ARM are shown in Table 1.

	Temporal Dimension	Residing Dimension	Stimulus Specificity	Categorization in ARM (Zhang 2013)
TISA	Constrained state	Person and Stimulus	N/A (state)	Temporally constrained, induced affective state, residing between person stimulus (cell 4)
Technostress	Unconstrained evaluation	Person and Stimulus	Outcome-based, specific stimulus	Temporally unconstrained, outcome-based, affective evaluation toward behaviors with a particular stimulus (cell 6.2)
Computer Anxiety	Unconstrained evaluation	Person and Stimulus	General stimulus	Temporally unconstrained, learned affective evaluation toward behaviors with a general, stimulus (cell 8)

Table 1: Conceptual Differences Between Key Concepts

Relationship between Technostress and TISA

Based on ARM, induced affective states are a potential intermediary between affective antecedences and affective evaluations, both general and specific. Further, TISA as a concept is readily generalizable to the study of the impact of technology use outside of business settings. At the early stages of technology use, affective evaluations are still being formed and so the induction of particular affective states can be expected to more strongly influence longer term affective outlooks and shape the individual's behavior e.g. discontinuance of use or the adoption of coping behavior. After using a system for a while, however, affective evaluations can be expected to be learned and therefore more stable. This does not change the fact that conditions in an episode of use can induce particularly positive or negative feelings above what has been learned in the past.

Based on ARM, a reciprocal relationship exists between states and affective evaluations (Zhang 2013), such as TISA and technostress. This is a state-trait connection that studies of stress and anxiety tend to avoid applying directionality to, rather than going with a more correlational view (e.g., Horikawa and Yagi 2012; Williams 1981). While technostress is a technology-level variable, TISA is an episode-level variable, a result of applying a specific technology to a specific task under a situation that may or may not resemble what the individual has previously learned or grown accustomed to. Thus, as users interact with a given technology, the degree to which they feel anxious during the episode of use will be correlated with the degree of technostress that they feel. Therefore:

H1: Technostress and technology induced state anxiety are positively correlated

Nomological Net of Technostress and TISA

Technology Characteristics

While the capabilities of computer technology have steadily improved over the past decades, so has the focus on making technology more easy and intuitive to use. Technology characteristics are central to the adoption, continuous use and even effectiveness of all technology. Of all possible characteristics, ease of use has been unequivocally shown to be a significant predictor of usage intentions (Davis et al. 1989) and attitudes towards computers (Todman and Dick 1993). Perceived usability represents a user's overall perception of how user-friendly the technology is. Given the power of human-centered design and the influence of technology characteristics on user outcomes, it is expected that the more a technology is perceived as usable, the less feelings of technostress and TISA the user might experience.

H2. Perceived usability is inversely related to technostress (H2a) and to technology induced state anxiety (H2b).

Individual Characteristics

Individual characteristics have been widely studied as antecedents of cognitive and affective outcomes. Concepts such as CA and computer self-efficacy have been widely used in the IS literature and are important IS-specific individual characteristics associated with usage intentions and performance. Earlier discussion and Table 1 distinguish CA from TISA and technostress conceptually. CA has been shown to be associated with broader individual characteristics such as negative affectivity, trait anxiety, computer playfulness and personal innovativeness in IT, and is therefore a good indication of general attitudes towards technology use. In fact, people who experience high levels of CA are considered likely to exhibit behavior such as computer avoidance. Zhang (2013) categorizes CA as a learned affective evaluation towards computer use *in general*, and proposes it will influence an individual's induced affective state (proposition 1 of ARM) and particular affective evaluations of specific technologies (proposition 5 of ARM).

H3. Computer anxiety is positively related to technostress (H3a) and to technology induced state anxiety (H3b).

Perceived Task Complexity

The characteristics of the tasks being performed are expected to influence both technostress and TISA, but to different degrees. Because technostress is a learned evaluation that is formed over time, it is influenced by multiple tasks carried out using the system. Therefore a specific task may not have a strong effect on technostress unless it is very representative of the range of tasks carried out using the system. TISA, on the other hand, being an induced state can vary between episodes of use, especially between tasks of different properties. The more complex a task is, the more the individual requires both cognitive and affective resources to complete it successfully. As such, it is expected that although task complexity is related to both technostress and TISA, task complexity has a greater effect on TISA than on technostress.

H4. Task complexity is positively related to technology induced state anxiety (H4a) and has a greater effect on TISA than on Technostress (H4b).

Impact on Performance

Previous studies have shown that technostress leads to reduced end-user satisfaction (Tarafdar et al. 2010), productivity, and performance (Tarafdar et al. 2015), all measured subjectively using self-reports. In this paper, it is proposed that this relationship between technostress and performance also holds for objective measures of performance such as task accuracy and time spent. However, because technostress is conceptually a more stable evaluation, it is less malleable after a long period of use of a given technology. Rather, TISA is expected to more strongly influence these same objective measures of performance in a similar pattern to technostress.

H5: The effect of TISA on task accuracy is greater than the effect of Technostress
H6: The effect of TISA on time spent is greater than the effect of Technostress

Methods

Scale Development

New scales were created to measure technostress and TISA by adapting existing scales from the psychology literature on stress. For TISA, the items in the full length State-Trait Anxiety Index (Spielberger et al. 1970) were retained with the instructions modified to reference the preceding technology interaction or task. For measuring technostress, the perceived stress scale (PSS; Cohen et al. 1983), a widely used and validated measure, was adapted by making the language match with the extant understanding of the nature of technostress (e.g., "*how often have you felt that you were unable to control the important things in your life?*" was modified into "*how often have you felt that you were unable to control the system as well as you want?*"). The new technostress measure was pretested using a sample (n=51) obtained from Amazon Mechanical Turk, after which four items with poor loadings were dropped. Both new scales are included in Table 2 below.

Experiment Design

To validate these new measures within their nomological net, a field experiment was carried out using student participants enrolled in an introductory business course. The study, conducted at the end of a semester of learning to use Microsoft Excel, involved performing an Excel based computing task. Between a pre-test and post-test, the experimental task was completed using SimNet, a simulator software designed for teaching Microsoft Excel (screenshot in Figure 1). Technostress was measured in the pre-test for two-thirds of the sample and in the post-test for the rest to ascertain the effect of measurement timing. To create variance in the TISA of participants, the study experimentally manipulated task complexity (high vs low complexity) by creating two tasks of different difficulty levels and randomly assigning participants to one of both tasks (see Table 3). Complexity and pre/post measurement of technostress were balanced. The simulation software measured time spent and performance accuracy.

New Measures	Items
TISA – based on the State-Trait Anxiety Index (Marteau and Bekker 1992; Spielberger et al. 1970)	While working on the Microsoft Excel task you just completed, how did you feel? • Calm (R) 0.77^ • Tense 0.85 • Strained 0.79 • At Ease (R) 0.83 • Worried over possible mistakes 0.68 • Self-confident (R) 0.78 • Nervous 0.75 • Indecisive 0.69 • Worried 0.80 • Confused 0.70 • Steady (R) 0.77 • Pleasant (R) 0.63
Technostress – based on Perceived Stress Scale (PSS; Cohen et al. 1983)	In this study you will be using Microsoft Excel within SimNet. Please answer by selecting how well the statement describes feelings you have felt towards using Excel in recent times. Think about the past month of active use of Excel when answering the questions that follow: • You have been upset because something happened unexpectedly when using Excel 0.73* | 0.60^ • You have felt that you were unable to control Excel as well as you want 0.78 | 0.70 • You have felt nervous and "stressed" because of Excel 0.69 | 0.76 • You have lost confidence in your ability to perform well using Excel 0.73 | 0.83 • You have felt that Excel was stopping things from going your way 0.77 | 0.87 • You have found that you could not cope with all the things that you had to do using Excel 0.88 | 0.87 • You have lost the ability to control irritations resulting from using Excel 0.86 | 0.86 • You have felt that you were NOT on top of things because of Excel 0.80 | 0.87 • You have lost the ability to control the way you spend your time when using Excel 0.86 | 0.87 • You have felt your difficulties with Excel piling up so high that you could not overcome them 0.85 | 0.86

* loading in MTurk sample ^ loading in experimental sample

Table 2: Scales Measuring TISA and Technostress

Condition	Task Details (Order randomized for all participants)
Low Complexity	Enter a formula in cell D5 to calculate B5/B4rounded to 4 decimal places.
	Create a 3-D pie chart from the selected data.
	Switch the rows and columns in the chart, so the data points are grouped into data series by year.
	Name cell B9 as follows: COLA
	Enter a formula in cell B7 to calculate the average value of cells B2:B6.
High Complexity	Create and apply a new conditional formatting rule to apply bold font formatting to only cells that are equal to or below the average for the selected range.
	Create and apply a new conditional formatting rule. Apply the default icon set Three traffic lights (unrimmed) icon set, but show only the icon, not the cell value. Change the values so the green circle icon (the first icon) will be applied if the cell value is >=90 percent and the yellow circle icon (the second icon) will be applied if the cell value is <90 and >=10 percent.
	Clear the selected Sparklines from the worksheet.
	Modify the chart so the Owner Draw data series is plotted along the secondary axis.
	Add the Bonus field to the PivotTable.

Table 3: Details of Low and High Complexity Tasks

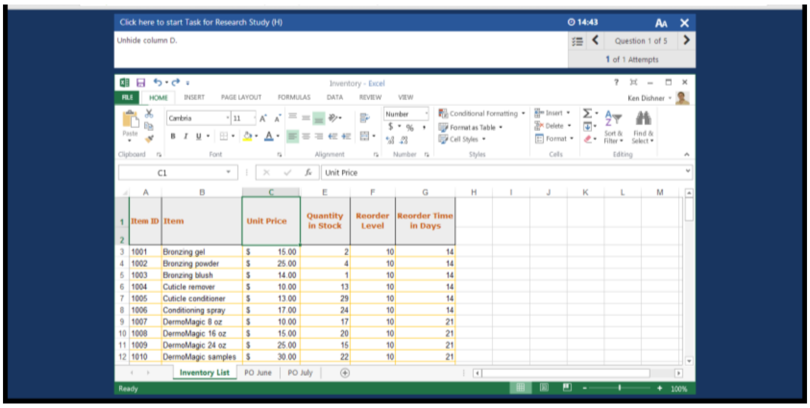


Figure 1: Screenshot of SimNet Software

Measures

Before the task, perceived usability (Barnes and Vidgen 2002), CA (Heinssen et al. 1987) and computer self-efficacy (Compeau and Higgins 1995) were measured using existing scales. After the task, TISA and perceived task complexity (also a manipulation check) were recorded. The new perceived technostress scale, and the two technostress-creator measures (techno-complexity and techno-overload; Tarafdar et al. 2007) were recorded in the pre-test in two-thirds of the sample and in the post-test for the rest of the sample, as previously described. Some antecedents of technostress more specific to business users were left out of this study. For instance, three technostress-creators (techno-invasion, techno-insecurity and techno-uncertainty) were excluded because they were not deemed relevant to the participant sample or the academic context of use. Further, perceptions of technology features (presenteeism, usefulness, pace of change, and anonymity) treated by Ayyagari et al (2011) were left out for the same reason.

Results and Analyses

Three hundred and forty students participated in the experiment, of which the data for 323 participants was complete. 95% of the sample were between 19 and 23 years old, with slightly over half (58%) being male. 93% of the sample reported having over five years of experience using computers. Further, 49% percent of the sample were assigned to the low complexity task (n = 158), while the rest were in the high complexity group (n=165). Significant differences existed with respect to perceived task complexity ($m_{\text{high complexity}} = 4.54$, $m_{\text{low Complexity}} = 3.02$, $F=144.99$, $p<0.000$). With respect to the time of measuring technostress, 62% of the sample (n = 201) reported technostress before beginning the task. There was no difference in any measures based on the time of measuring technostress so all analyses are run using the full sample.

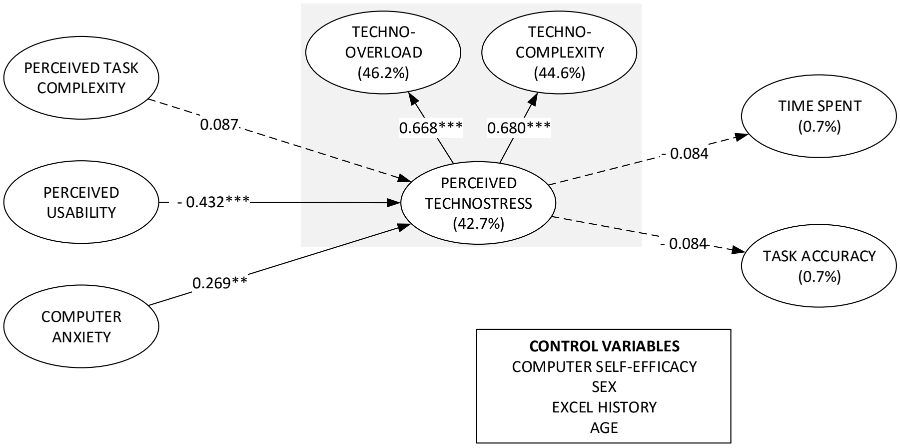
Analyses were conducted in SmartPLS 2.0 (Ringle et al. 2007) using partial least squares (PLS) modeling, a recommended methodology for exploratory research known to be robust for small to medium sample sizes (Gefen and Straub 2005; Hair et al. 2013). Two models were specified in sequence, first a model with technostress and its hypothesized antecedents and outcomes only, and then a second model which included TISA. The results from both models are shown graphically in Figure 2 below.

Before the relationships in a PLS model can be analyzed, the measurement model first has to be assessed. Except for seven items in the computer self-efficacy scale used (Compeau and Higgins 1995), all other items in the model cleared the recommended 0.5 cut off for factor loadings and significant non-zero outer weights. Every latent variable had Cronbach alpha above 0.78 and AVE above 0.57 (except computer self-efficacy, AVE = 0.21). Further, by comparing the item loadings and cross-loadings across all latent variables the convergent validity of the new technostress measure and techno-complexity and techno-overload was shown, with items for each construct loading highest on the latent variable it was measuring. Further discriminant validity between variables was observed. These findings were further confirmed by inspecting the latent variable correlations. For instance, perceived technostress and both technostress-creators were highly correlated ($r > 0.67$), while TISA and technostress were moderately positively correlated ($r = 0.35$). Because PLS-SEM does not test reciprocal relationships, without the use of simultaneous models such as two-step PLS, the bivariate correlation estimate was taken as support for H1. The full inter-construct correlation table confirming the integrity of the measurement model is shown below.

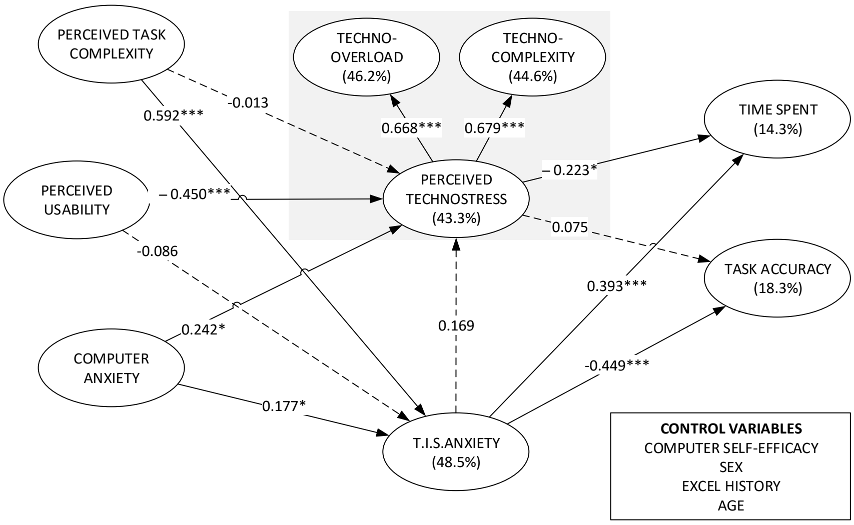
After model 1 was fit, a bootstrap of 5,000 samples was run to estimate the significance of the model paths ($p<0.05$). Perceived Technostress was shown to effectively represent a higher order formative latent construct that captured both technostress-creators measured (shaded portion of Figure 2a and 2b). Perceived usability and computer anxiety were found to significantly influence technostress (H2a and H3a supported), while the path from perceived task complexity to technostress was insignificant ($p=0.327$). Also, technostress was related to neither time spent nor task accuracy. Given these findings, the second model with TISA included was tested. While the link from perceived usability to TISA was non-significant (H2b not supported), the links from computer anxiety and perceived task complexity were significant (H3b and H4a supported). Further, TISA was found to significantly predict both time spent and task accuracy in the hypothesized directions. Adding TISA to the model increased the variance explained in time spent on task (task accuracy) from 0.7% (0.7%) to 14.3% (18.3%) (H5 and H6 supported). Interestingly, adding TISA to the model also made the path between technostress and time spent statistically significant, indicating that TISA helps clarify the effect of technostress on time spent on the computing task. The path between TISA and perceived technostress in model 2 was not statistically significant ($p=0.141$). An alternative model, with the path between TISA and technostress reversed, was also tested and confirmed to be identical to the model reported above. This finding is discussed further in the next section. Finally, a one-way ANOVA was conducted to test the differences between means of technostress and TISA measures in the high and low complexity conditions as support for H4b. Results show that the manipulation had a significant effect only on TISA (Table 5). Table 6 shows all research hypotheses and indicates the ones which were supported.

	Alpha	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Age	-	-											
(2) Computer S-Effic	0.84	0.01	0.46										
(3) Computer Anxiety	0.82	-0.10	-0.17	0.81									
(4) Excel Experience	-	0.06	0.20	-0.16	-								
(5) Task Accuracy	-	-0.03	0.10	-0.08	0.12	-							
(6) Sex (Female = 1)	-	-0.04	-0.06	0.12	-0.09	-0.07	-						
(7) TISA	0.88	0.04	-0.18	0.30	-0.16	-0.42	0.17	0.76					
(8) Time Taken	-	0.14	0.06	0.01	-0.18	-0.35	0.04	0.31	-				
(9) Excel Usability	0.91	-0.03	0.41	-0.32	0.27	0.07	-0.16	-0.29	0.02	0.79			
(10) Task Complexity	0.78	-0.01	-0.14	0.14	-0.16	-0.60	0.08	0.65	0.37	-0.20	0.84		
(11) Perceived Technostress	0.94	-0.11	-0.26	0.44	-0.22	-0.08	0.07	0.35	-0.08	-0.57	0.22	0.80	
(12) Techno-Complexity	0.82	-0.01	-0.32	0.43	-0.28	-0.09	0.16	0.29	0.02	-0.58	0.19	0.68	0.81
(13) Techno-Overload	0.86	-0.07	-0.30	0.34	-0.25	-0.07	0.06	0.20	-0.03	-0.52	0.13	0.67	0.79

Table 4: Inter-Construct Correlations and Square Root of AVE (diagonal elements)



Model 1: Without TISA



Model 2: With TISA Included

Figure 2a & 2b: Plots of Structural Model

	Low Complexity (N = 158)		High Complexity (N = 165)		Results	
	Mean	S.D.	Mean	S.D.	F	Sig
Techno-Complexity	3.32	1.25	3.25	1.25	0.28	0.595
Techno-Overload	3.00	1.14	2.94	1.10	0.21	0.649
Perceived Technostress	3.15	1.23	3.06	1.19	0.48	0.487
TISA	3.60	0.93	4.45	0.84	72.71	0.000

Table 5: One-Way ANOVA between Low and High Complexity Conditions

Hypothesis Summary	Result
H1: Technostress and TISA are positively correlated	Yes
H2: Perceived usability is inversely related to (a) technostress (b) TISA	Yes No
H3: Computer anxiety is positively related to (a) technostress (b) TISA	Yes Yes
H4a: Task complexity is positively related to TISA and (b) has a greater effect on TISA than on Technostress	Yes Yes
H5: The effect of TISA on task accuracy is greater than the effect of Technostress	Yes
H6: The effect of TISA on time spent is greater than the effect of Technostress	Yes

Table 6: Research Hypotheses and Findings

Discussion

In this study, a new measure of perceived technostress is created and validated. Importantly, this measure is shown to exhibit convergent validity with two technostress-creators from previous research (techno-complexity and techno-overload), while also showing discriminant validity from CA and TISA, a result anticipated based on the theoretically-grounded delineation of affective concepts provided by ARM.

Theoretical implications of this work include the following: First, prior research on technostress-creators is shown to converge with a newly created reflective measure, thus laying a foundation for testing other technostress-creator dimensions and antecedents in a broad range of contexts. Second, the concept of TISA is introduced and shown to be distinct from technostress and CA. This provides empirical support for the propositions of ARM, a critical contribution as such conceptual clarity helps researchers avoid incorrect choices of focal variables in future research programs in this area. For instance, experimental research and human-computer interaction studies will do well to consider TISA as distinct from technostress and more malleable in experimental situations, and potentially more aligned to neurophysiological effects such as elevated cortisol levels, and increased heartrate. Third, the nomological validity of TISA, technostress and CA, and their influence on objective performance outcomes is shown, for the first time in the IS literature. Specifically, TISA is found to clarify the influence of technostress on time spent, an important outcome variable for technology users. As current findings suggest that TISA may be responsible for negative (objective) performance and physiological effects, future research on technostress should focus on other potential direct consequences, such as resistance behavior.

One finding in need of further exploration is the insignificance of the theoretically suggested link between TISA and technostress in the PLS-SEM model. At least one possible explanation exists for this. Because the study was conducted after several weeks of training in the use of Microsoft Excel, it is possible that wide differences no longer existed in perceptions of technostress among the sample. This aspect of the research context was useful in distinguishing technostress from TISA, but was less useful for showing the link between both variables. This observation is critical for shedding light on boundary conditions beyond which relationships proposed in ARM may not hold. As a future direction, this study will be conducted both at the start and the end of training participants to use a particular system to determine how affective responses are shaped by growing experience.

Several practical implications from this work exist: First, successfully establishing a distinct state variable, TISA, provides a point of intervention for reducing negative experiences with technology. By identifying induced affective states as a critical aspect of the process by which individual, technology and task characteristics impact performance, targeted interventions that empower individuals to regulate their emotional states can be tested in future research. Second, this paper demonstrates how objective performance measures such as task accuracy and time spent are impacted by technostress and TISA. TISA reduced task accuracy and increased time spent on the task, while technostress reduced time spent only. Paired together, these findings suggest two different pathways by which affective evaluations impact effort or time spent. While high levels of anxiety may actually increase the time users spend on a task, high levels of technostress may work in the opposite direction, reducing individuals' effort on the same task. Managers need to be aware of the various ways negative affect may influence worker's performance. Third, this work shows that technostress and TISA are a valid concern in the classroom as well as in the workplace.

The main limitation of this study is the lack of temporal separation between the two principal affective concepts – technostress and TISA. Future studies will employ a longitudinal design to determine whether TISA at time t influenced technostress reported at time $t+1$. Future research will also hypothesize and test for mediating relationships and the seeming suppression of the link between technostress and performance by TISA. Also, future research will look into the use of objective measures of TISA alongside self-report measurement scales. Objective, physiological measures of stress, such as salivary alpha-amylase levels, are likely indicators of TISA, rather than technostress, and prior research has shown that similar measures of state anxiety correlate with such physiological measure of stress (Noto et al. 2005; Takai et al. 2004).

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