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RESEARCH PAPER

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Concentration, Competence, Confidence, and Capture: An Experimental Study of Age, Interruption-based Technostress, and Task Performance

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Abstract

The proliferation of information and communication technologies such as instant messenger has created an increasing number of workplace interruptions that cause employee stress and productivity losses across the world. This growth in interruptions has paralleled another trend: the graying of the workforce, signifying that the labor force is aging rapidly. Insights from theories of stress and cognitive aging suggest that older people may be particularly vulnerable to the negative consequences of interruptions. Hence, this study examines whether, how, and why technology-mediated interruptions impact stress and task performance differently for older compared to younger adults. The study develops a mediated moderation model explaining why older people may be more susceptible to the negative impacts of technology-mediated interruptions than younger people, in terms of greater mental workload, more stress, and lower performance. The model hypothesizes that age acts as a moderator of the interruption-stress relationship due to age-related differences in inhibitory effectiveness, computer experience, computer self-efficacy, and attentional capture. We refer to these age-related differences as concentration, competence, confidence, and capture, respectively, or the four Cs. We tested our model through a laboratory experiment with a 2 x 2 x 2 mixed-model design, manipulating the frequency with which interruptions appear on the screen and their salience (e.g., reddish colors). We found that age acts as a moderator of the interruption-stress link due to differences in concentration, competence, and confidence, but not capture. This study contributes to IS research by explicitly elucidating the role of age in IS phenomena, especially interruption-based technostress.

Keywords: Age, Older, Technostress, Performance, Cognition.

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1 Introduction

Laura Oldfellow, who just turned 67, has to use information and communication technologies (ICTs) to support her work as a sales manager. Like many older people, she has a positive attitude toward ICTs and believes they are useful for her job, but she faces trouble in using them effectively—in contrast to Frank, a 25-year-old sales agent who grew up surrounded by ICTs (Czaja et al., 2006; Greengard, 2009). Laura is especially bothered by frequent interruptions, such as unexpected text messages and emails; as many older adults, she finds them disruptive to mental work (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008). While Laura knows that she could improve her interaction with the technology slightly by using the few *accessibility options for older people it provides, she resents being required to click on a handicap icon to access these options—after all, she is a proud senior citizen who considers herself to be in good health (Brown, 2002; Greengard, 2009). As a result of these problems, Laura is frustrated and feels that technology threatens her well-being and workplace performance, assuming, "It's not for me, I am too old!" (Brown, 2002). Many older people share her experiences and think the computer age has passed them by* (Brown, 2002; Tams & Dulipovici, forthcoming).

This vignette illustrates the potential interdependency of two emergent trends across the world: the "graying" of the workforce and the pervasive growth of ICTs in organizations (Panek, 1997, p. 363; Zimmer, Tams, Craig, Thatcher, & Pak, 2015). The OECD[1] reports that all of its member countries are experiencing fast population and workforce aging (OECD, 2013). In fact, the number of older workers across the OECD member countries has grown from 15,906,000 in the year 2000 to 24,548,000 in 2012, an increase of more than 50% (OECD, 2016). Notably, for reasons such as legislation against age discrimination, older individuals will participate in the workforce at sharply increasing rates over the next several decades (OECD, 1998, 2011).

While the workforce has aged, technology has dramatically increased the number of interruptions experienced by employees at work (Spira & Feintuch, 2005). These interruptions have evolved from irregular phone calls, post-it notes, and walk-in traffic, to a continuous stream of instant messages, email notifications, meeting reminders, task reminders, and other interruptions, all mediated via a multitude of technological devices that constantly beep, buzz, and blink. Due to their constant calls for employees' attention, these technology-mediated interruptions have grown to consume more than a third of the work day (Spira & Feintuch, 2005). In this interruption era, ICTs leave employees struggling to accomplish their primary work responsibilities and tasks. Employees' struggle, in turn, can impact their well-being and productivity (Galluch, Grover, & Thatcher, 2015; Tams & Dulipovici, forthcoming; Tams, Thatcher, & Ahuja, 2015).

As technology creates more frequent interruptions, there is some indication that older users may feel particularly overwhelmed and frustrated (Greengard 2009; Tams, 2014; Tams & Hill, 2016). To better understand the implications of an increasing frequency of interruptions for a graying workforce, the present study focuses on the intersection of aging, stress, and performance in ICT-enabled environments. Its working thesis is that older adults are more bothered by interruptions than younger adults due to age-related declines in certain cognitive abilities (Hasher & Zacks, 1988). This working thesis also implies related deficits in task performance. A mediated moderation model is put forth to examine not only whether interruptions impact stress and task performance differently for older compared to younger adults but also how and why older adults might respond differentially to this and related ICT stressors.

In investigating the interplay of age with stress and ICT, we make important contributions to IS research. Perhaps most importantly, we study aging as a substantive variable rather than merely a control. Based on the facts that age is considered a "key demographic variable" in IS research (Venkatesh, Morris, Davis, & Davis, 2003, p. 469) and that few IS studies focus on age (Tams, Grover, & Thatcher, 2014; Wagner, Hassanein, & Head, 2010), a research agenda encouraged IS scholars to theorize "touch points of age" (Tams, Grover, & Thatcher, 2014, p. 286). Touch points of age constitute theoretical points through which age touches on various IS phenomena. This notion implies that age should be modeled as an indirect (i.e., mediated) moderator of IS relationships, with an added mediator explaining precisely how and why a given IS relationship depends on age. In the present study, we follow closely the notion of "touch points of age" (Tams, Grover, & Thatcher, 2014, p. 286). We construct a mediated moderation model that examines four such touch points. They are: inhibitory effectiveness, computer experience, computer self-efficacy, and attentional capture, to which we refer as *concentration*, *competence*, *confidence*, and *capture*, respectively, or the "four Cs." Examining the role of age in technostress through these different touch points is important in order to avoid founding our age-related conclusions on stereotypical accounts. Instead, the four touch points allow us to shed ample light on the theoretical nature of the role that age plays in the technostress phenomenon.

Furthermore, research on technostress (i.e., the stress experienced by individuals as a result of their ICT use) often assumes that ICTs create stress in a universal fashion, largely disregarding individual differences (Tams, 2015). Yet, seminal stress research (e.g., Lazarus, 1999) emphasizes that stress arises from an individual's reaction to a stimulus shaped by cognitive processes associated with stressor recognition (e.g., selective attention) and assessment (e.g., self-efficacy), not from the specific stimulus per

[1] Organisation for Economic Co-operation and Development. The OECD was founded in 1961 with the twin goals of stimulating the economic progress of its member countries and world trade.

se. This notion implies a moderation argument. While prior technostress research has studied technostress inhibitors, these were not modeled as moderators of the stressor-stress relationship, implying that they could not show whether or in what way the impact of ICT stressors on stress depended on individual differences. Hence, by elucidating to what extent individuals' stress responses to interruptions may depend on age-related differences in certain cognitive abilities, the study reported here represents an important improvement in the modeling and subsequent understanding of interruption-based technostress (please also see Table 7 in Section 7). To this end, the study employed a laboratory experiment with a 2 x 2 x 2 mixed-model design, in which the frequency with which interruptions appear on the screen and their salience (e.g., reddish colors) were manipulated. We deemed the latter manipulation relevant for this study because it has been suggested that salience impacts the extent to which stimuli, such as interruptions, capture attention, and because significant age differences might exist in individual sensitivities to these attentional capture effects (Fisk, Rogers, Charness, Czaja, & Sharit, 2009).

This paper unfolds as follows. The next section reviews prior research to frame a parsimonious research model. The third section develops the model, an integrative mediated moderation model of ICTs, aging, stress, and task performance, grounded in major theories of stress and cognitive aging. This model indicates that older people are bothered by interruptions in a different way, experiencing greater mental workload and, in turn, more stress and lower performance than younger individuals. The remaining sections detail the laboratory experiment used to test the model as well as the study results.

2 Literature Review

To understand the implications of interruptions for age-related differences in stress and performance, we situate our study in three research streams: stress, human cognition, and cognitive aging. Our goals in reviewing stress research are threefold: to identify an appropriate theoretical frame for the stress component of this study; to examine computer self-efficacy (CSE) as a potential coping mechanism, since CSE is pertinent to both stress and aging (Bandura, 1989; Lazarus, 1999; Marakas, Yi, & Johnson, 1998); and to assess how age has been treated in prior technostress research. Next, we review relevant research on human cognition to understand more fully why interruptions may lead to stress, enabling us to identify three additional mechanisms by which aging may impact technostress. These mechanisms are attentional inhibition, attentional amplification, and computer experience. The latter is pertinent to this study because it may reduce the cognitive requirements of computer-based tasks and may have an important link to age (Appendix A details why we treated computer experience and CSE as largely distinct). Finally, we examine the impact of aging on the previously identified four cognitive mechanisms.

To identify the cognitive mechanisms through which aging may impact technostress (i.e., attentional inhibition, attentional amplification, computer experience, and computer self-efficacy), the literature review followed the human information processing model (Wickens, Lee, Liu, & Becker, 2004). This model is consistent with pertinent stress theories (e.g., the transaction-based model, Folkman & Lazarus, 1984), and it explains the cognitive mechanisms at play in the process whereby environmental stimuli (e.g., interruptions) provoke responses from individuals (e.g., stress-related responses). According to this model, information about the environment is first perceived and then processed, before responses to the information are selected. These elements of information processing (perception, processing, and response selection) interact such that (1) what information is being processed depends on how it is perceived, and (2) what responses are selected depends on how information is interpreted (Wickens et al., 2004).

According to the information processing model, three perceptual processes are responsible for the perceptual encoding of environmental stimuli; namely, attentional inhibition and attentional amplification as elements of selective attention, and past experience (Wickens et al., 2004). Perception begins by selectively attending to environmental stimuli through attention to either inhibition or amplification. These two processes of selective attention govern separately what information is selected for information processing. Information processing, in turn, generally requires cognitive effort (Wickens et al., 2004). Yet, a stimulus can be processed automatically with reduced cognitive effort to the extent that past experience makes a stimulus familiar to the perceiver (Wickens et al., 2004). Information processing takes place in working memory (i.e., a temporary, effort-demanding storage) and, as indicated earlier, it depends on how the information was perceived (e.g., fewer working memory resources are needed if a stimulus passed by unnoticed or if an individual has familiarity with some aspects of the environment) (Wickens et al., 2004). Thus, it is the interaction between environmental stimuli and perceptual processes that generates working memory demands, ultimately creating a response such as stress (Wickens et al., 2004). However, response selection is not a simple function of information processing; it depends on how information is interpreted. A pertinent factor in the context of information processing and stress is self-efficacy (Bandura, 1997; Wickens et al., 2004), which governs whether processed information is interpreted as a threat.

In contrast to our approach integrating stress, human cognition, and cognitive aging in an ICT context, most prior research has examined these concepts in isolation. Although a few studies have looked at the intersection of two such areas (e.g., the intersection between technostress and aging), no research to date has examined the point at which all three research areas intersect. It is precisely this point that yields the greatest potential for explaining age-related differences in technostress and subsequent performance outcomes (Warburton, 1979).

2.1 Stress Research

Stress refers to the "relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources" (Folkman & Lazarus, 1984, p. 19). Consistent with recent technostress research (e.g., Ayyagari, Grover, & Purvis, 2011; Galluch et al., 2015), this definition implies that when a person lacks coping resources (i.e., the ability to deal with stressful events), stress arises from a misfit between resource supply and demand. An important example of this view of stress is the person-environment fit perspective (French, Rodgers, & Cobb, 1974; French, Caplan, & Van Harrison, 1982), a prominent theory concerned with how perceptions of fit between a person and his or her work lead to stress. The extent of fit or misfit is a function of perceived mental workload, which is the perceived relative balance between environmental demands per unit time, or demand frequency (e.g., the frequency with which interruptions occur), and a person's mental resources (e.g., deciding, calculating, remembering) available for responding to these demands (Kaldenberg & Becker, 1992; Lazarus, 1999; Warburton, 1979). While mental workload increases with the frequency of environmental demands, it, in turn, is strongly linked to stress. This is especially true for excessive demands from, for example, frequent interruptions in addition to the regular task demands. The theory further suggests that stress reduces performance (French et al., 1982; Warburton, 1979).

However, the effectiveness of stressors like perceptions of excessive mental workload in causing stress depends on a person's ability to deal or "cope" with them (Van Harrison 1985). Coping refers to the cognitive effort needed to manage specific demands that are perceived as exceeding cognitive resources. As such, it can be modeled as a moderator of the mental workload-stress link (Folkman & Lazarus, 1984), implying that the effect of mental workload on stress *depends on* the availability of coping resources. Major coping resources are self-efficacy beliefs (Bandura, 1997; Lazarus, 1999), implying that peoples' computer self-efficacy (CSE) may interact with mental workload to impact technostress. More specifically, according to self-efficacy theory (Bandura, 1989, 1997) and coping theory (Lazarus 1999), self-efficacy affects thinking processes, allowing people to cognitively cope with stressors. Thinking processes (e.g., positive thinking) are affected since people anticipate likely outcomes of computer usage (e.g., positive outcomes) on the basis of their CSE. These cognitive representations of future events serve to regulate feelings of threat in the present (Bandura, 1989, 1997; Lazarus, 1999). For example, self-efficacy can positively color the cognitive interpretation of stressful events, rendering them less stressful. This concept implies that the effect of mental workload on stress may *depend on* CSE, making CSE a potential *moderator*—consistent with the concept of coping as introduced above.[2]

Although coping is an integral part of the stress process (Galluch et al., 2015; Maier, Laumer, Weinert, & Weitzel, 2015) and CSE is a major coping mechanism, neither concept has received much attention in technostress research. CSE is a particularly relevant coping mechanism for this study because age may be an important antecedent to it (Marakas et al., 1998). Since CSE principally reflects individuals' confidence regarding computer use (Bandura, 1982; Compeau & Higgins, 1995), it is referred to in this study as *confidence*.

Given that the person-environment fit theory is a transactional approach that centers on perceptions of fit, it gives "full recognition" to individual differences, such as age (Blau, 1981, p. 280; Lazarus, 1999). Hence, the person-environment fit theory is appropriate for studying the impact of age on technostress.

To identify prior research examining the impact of age on technostress, we conducted a literature search

[2] Bandura (1989, p. 730) indicates that "people's beliefs in their capabilities affect how much stress and depression they experience in threatening or stressful situations" and that "the level of affective arousal in situations involving stressors is influenced by perceived self-efficacy." This concept implies that self-efficacy plays a role in individual stress responses only when a stressor is present (i.e., "in situations involving stressors") since the stressor is "the initiating factor in the stress phenomenon" (Warburton, 1979, p. 469) and since self-efficacy only matters in a stressful context. More specifically, when people have a high regard for their ability to do what is required, or high confidence in themselves, stressors are less likely to generate stress because anxiety as a stress emotion is less likely to occur and will be weaker. This question of *when* engenders a moderation argument (MacKinnon & Luecken, 2008) consistent with the concept of coping (Folkman & Lazarus, 1984).

for published, empirical papers in Academic Search Complete (EBSCO) and Business Source Complete (EBSCO). This search used the keywords a*ge*, *stress*, *information technology*, *information systems*, *computer*, and *smartphone* in the abstract and title of published papers, and it yielded 23 different results. We, then, removed all articles that were not relevant because they did not focus on the age of technology users but, for example, on the "electronic age" (e.g., Crawford, 1989), on interest rates in South Asian countries (Myrdal, 1966), or because they were not empirical in nature (e.g., Soleimani, Mokhtari-Dizaji, Saberi, & Sharif-Kashani, 2015). As a result, we obtained a set of four articles. Using pertinent keywords from these four articles, we conducted another search. In this second search, we used the same set of keywords, except that we replaced the keyword age with *older*. This second search identified one more relevant article. Thus, we obtained a final set of five published, empirical studies (see Table 1). While these studies consistently found age differences in technostress, the results were contradictory. Some studies (Czaja, Sharit, Nair, & Rubert, 1998; Ragu-Nathan, Tarafdar, Ragu-Nathan, & Tu, 2008) found that technostress decreases as age increases, whereas others (Tu, Wang, & Shu, 2005; Wang, Shu, & Qu, 2008) found the opposite. In addition, perhaps because past research did not employ theories of aging, the predictions and findings within several studies were also inconsistent (Czaja et al., 1998; Ragu-Nathan et al., 2008; Sharit et al., 1998). Thus, reexamining the role of age in technostress seems warranted.

Table 1. The Treatment of Age in the Technostress Literature

Source	Treatment of age	Theories used	Age-related prediction	Age-related theoretical justification	Age-related findings
Czaja et al. (1998)	Substantive variable	None	Older compared to younger people experience more technostress	None	Technostress decreases with age
Ragu-Nathan et al. (2008)	Substantive variable	Transaction-based model of stress, which is not concerned with age-related differences	Older and younger people experience the same levels of technostress	None	Technostress decreases with age
Sharit et al. (1998)	Substantive variable	None	Older compared to younger people experience more technostress	Declines in cognitive abilities along with reduced user experience can make older compared to younger people more vulnerable.	Technostress decreases with age for data entry tasks and increases with age for account balancing tasks.
Tu et al. (2005)	n/a	None	n/a	n/a	Technostress increases with age
Wang et al. (2008)	Control variable	None	n/a	n/a	Technostress increases with age

n/a = not applicable because no prediction was made

Table 1 (cont.). The Treatment of Age in the Technostress Literature

Source	Explanation of age-related findings	Theory of aging used?	Within-study inconsistency?	Cross-study inconsistency?
Czaja et al. (1998)	None	No	✓	Technostress decreases with age
Ragu-Nathan et al. (2008)	Possibly longer organizational tenure of older employees results in more firm-specific experience and an improved understanding of how to assimilate the effects of ICTs in the work environment. The authors note that this result could be sample-specific.	No	✓	
Sharit et al. (1998)	Potential declines in such cognitive abilities as working memory can perhaps make older compared to younger people more vulnerable to mentally challenging tasks.	No	✓	
Tu et al. (2005)	Older compared to younger people often think more rigidly and more strongly "stick" to conventional work environments and procedures. Technological change challenges their greater mental resistance to change. Also, learning capacity can decrease with age.	No	n/a	Technostress increases with age
Wang et al. (2008)	None	No	n/a	

n/a = not applicable because no prediction was made
Within-study inconsistency = inconsistency between a study's prediction and findings
Cross-study inconsistency = inconsistency across different studies

2.2 Human Cognition

To understand more fully why interruptions may impact mental workload, we draw on the interrelated concepts of working memory, selective attention, and domain-specific experience from the human information processing model introduced earlier (Wickens et al., 2004). Working memory is a temporary storage and processing element in the brain that holds the information necessary to complete an active task. For example, once a phone number has been looked up, it is held in working memory until it is fully dialed (Wickens et al., 2004). However, the capacity of working memory is limited, at times to as few as one item (Dumas & Hartman, 2008). Hence, as people attend to interrupting stimuli, and access their working memory, the capacity available for task-related processing declines. As a result, task-related mental work slows and becomes error-prone (e.g., slow and incorrect dialing).

Selective attention refers to the ability to selectively process some information sources while ignoring others (Strayer & Drews, 2007), ensuring that only relevant stimuli enter working memory. To this end, selective attention utilizes two mechanisms, inhibition (i.e., goal-directed top-down) and amplification (i.e., stimulus-driven bottom-up) (Houghton & Tipper, 1994). These two mechanisms work concurrently such that inhibition suppresses irrelevant stimuli, while amplification selects relatively salient stimuli to enter working memory. For instance, in an ICT store, people may be actively trying to ignore information unrelated to the Apple iPhone they are looking for (goal-directed attention or inhibition); yet their attention may still be captured involuntarily by the red light next to the generic smartphone (stimulus-driven attention or amplification) (Christ et al., 2008).

We refer to the inhibition mechanism as *concentration* since it helps people concentrate on the task at hand. For example, in a study conducted by Simons and Chabris (1999), subjects watched a film showing two teams passing a ball back and forth. They were asked to report how often the team wearing the white shirts passed the ball. In the middle of the clip, a person in a gorilla costume walked into the scene, stood right in the center of the players, and beat his chest before leaving. Remarkably, 58 percent of the participants did not see the gorilla. As this result suggests, attentional inhibition can be effective for filtering out irrelevant stimuli, leaving more working memory resources for task-related processing.

The amplification mechanism emphasizes relatively salient stimuli so that they are more likely to capture peoples' attention than nonsalient ones (Huang & Pashler, 2005). Consequently, we refer to this concept as *capture*. To illustrate, amplification is often referred to as a "spotlight" (Houghton & Tipper, 1994, p. 59) since, like the beam of a spotlight, it directs attention toward relatively salient information. Traffic lights serve as an example: as the light gradually approaches red, it triggers stronger attentional responses so that it is more likely to be noticed (Luoma et al., 1997). Hence, relatively salient interruptions may be more likely to be noticed, thus entering working memory and leaving fewer working memory resources for task-related processing.

To fully understand the technostress phenomenon from an information processing and workload perspective, computer experience needs to be considered as a factor that may reduce the requirements of a task for working memory resources (Rogers & Fisk, 2001). The axiom "practice makes perfect" illustrates this idea, implying that as tasks become more automatic due to increasing experience, they demand fewer such resources. Consequently, at high levels of experience, interruptions may draw working memory resources away from a task without disrupting performance (Sweller, 1994), a concept referred to here as *competence*. Yet, despite the recognized potential of computer experience to mitigate technostress (Tarafdar et al., 2007), research on the role of computer experience in technostress is lacking.

As this analysis suggests, confidence, concentration, capture, and competence can perhaps explain how interruptions can impact stress and performance outcomes and for whom. As such, these mechanisms offer a useful way to frame the impact of aging on technostress.

2.3 Cognitive Aging

Cognitive aging research examines age-related changes in selective attention and working memory (Park, 2000). We first turn to the inhibitory deficit theory of cognitive aging (Hasher & Zacks, 1988), which is a major theoretical approach to aging (Smith 1996) that explains how and why age can impact the active control of the contents of working memory. According to this theory, the inhibitory mechanism of selective attention serves two complementary functions: bringing extraneous information to focal attention and deleting such information from attention (Hasher et al., 1999). The access function suppresses the processing of interruptions when the interruption first occurs, while the deletion function serves to quickly remove attended-to but rejected information from attention. This theory suggests that both these functions are impaired in older individuals so that interruptions are more likely to attract focal attention, enter working memory, and disrupt cognitive processing. As a result, older adults are differentially "bothered" by interrupting stimuli (Zacks & Hasher, 1997, p. 275).

Further, recent research shows that older adults' working memory capacity tends to be more negatively affected by salience such as reddish colors than that of younger people due to increased sensitivity of attentional amplification (Fisk et al., 2009). Hence, interruption salience is a mechanism by which age may impact technostress due to its dependence on attentional amplification (which increases with age) and its influence on resource availability, potentially resulting in stronger detrimental impacts on mental workload perceptions and the subsequent manifestation of stress and performance outcomes.

Regarding computer experience, it has been suggested that older people may generally have very limited or even no experience (Fisk et al., 2009). As a result, older adults may require more working memory resources to accomplish computer-based tasks than younger adults, potentially resulting in more stress and lower performance. Similarly, older adults may have limited CSE since "in cultures that revere youth and negatively stereotype the elderly, age becomes a salient dimension for self-evaluation" (Bandura, 1986, p. 418). It has also been suggested that age-related changes in cognitive abilities threaten older adults' beliefs in their ability to deal with the cognitive demands involved in computer work (Reed et al., 2005), potentially limiting their CSE. Consistent with this conclusion, Marakas et al. (1998) suggested that age may be an important determinant of CSE.

Figure 1 (see Appendix) shows how the preceding review frames a powerful yet parsimonious research model. The stress literature offers a core model connecting technology, stress, and performance, and it suggests that CSE may serve as a coping mechanism that could have an important relationship with age. Research on human cognition offers additional constructs with the potential to explain why interruptions may impact older people differentially. In summary, this review suggests that the four mechanisms of confidence, concentration, capture, and competence, identified through the human information processing model (Wickens et al., 2004) and referred to here as the *four Cs*, potentially moderate the negative impacts of ICTs; yet, due to differential availabilities of these four moderating mechanisms across age groups, older and younger adults may reap differential benefits from them. Thus, the term *four Cs* provides a context for this research; it represents a formal and precise way to summarize potentially relevant factors involved in explaining the role of age in interruption-based technostress.

3 Research Model

Based on person-environment fit theory, our research model suggests that interruptions increase mental workload perceptions, which, in turn, impact stress and task performance (see Figure 2 in the Appendix). The model further proposes, consistent with the person-environment fit theory, that age-related impacts on technostress arise from age-related differences in concentration (inhibitory effectiveness), competence (computer experience), confidence (CSE), and capture (interruption salience). More specifically, the age-related manifestations here referred to as *concentration*, *capture*, and *competence* pertain to the link between the frequency of interruptions and mental workload since this link is concerned with mental resource availabilities (Folkman & Lazarus, 1984; Warburton, 1979). The age-related manifestation here referred to as *confidence* pertains to the link between mental workload and subsequent experiences of stress since this link is concerned with belief-systems and thinking processes (e.g., positive thinking) (Bandura, 1989; Lazarus, 1999). Definitions for all constructs are offered in Table 2. To formally develop this integrative research model, we first introduce a core model of technostress that conceptualizes the causal chain between interruptions, stress, and performance. Subsequently, we refine this core by elucidating the four Cs that epitomize the various ways by which the impact of age on technostress may manifest itself.

Table 2. Construct Definitions

Construct	Definition
Frequency of T-M interruptions	Number of technology-mediated (T-M) interruptions in a given time interval (Basoglu & Fuller, 2007; Warburton, 1979).
Perceived mental workload	Perceived ratio of mental resources required to accomplish a task (e.g., working memory capacity) to mental resources available (French et al., 1982; Hart & Staveland, 1988; Warburton, 1979; Wickens et al., 2004).
Stress	Extent to which an individual responds to a perceived misfit between resource availability for task performance and environmental resource demands (French et al., 1982; Lazarus, 1999).
Task performance	Extent to which an individual's task output is effective in meeting task objectives (Burton-Jones & Straub, 2006).
Inhibitory effectiveness	Extent to which an individual can deliberately inhibit or down-regulate the processing of interrupting stimuli, preventing them from gaining access to mental resources (e.g., working memory). An inhibitory deficit implies higher susceptibility or vulnerability to interruptions (i.e., lower selective attention performance) (Hasher & Zacks, 1988; Tams, Grover, Thatcher, & Ahuja, 2017).
Computer experience	Extent to which an individual has been using computers over his or her lifetime (Harrison & Rainer, 1992; Taylor & Todd, 1995; Tams, 2017).
Computer self-efficacy	Extent to which an individual believes in his or her ability to successfully use a computer in support of work tasks (Compeau & Higgins, 1995).
Salience of T-M Interruptions	Extent to which T-M interruptions appeal to the attentional amplification mechanism due to their color (Houghton & Tipper, 1994; Strayer & Drews, 2007; Wickens et al., 2004).
Age	Chronologically younger individuals compared to older individuals (Hasher et al., 1991; Hasher & Zacks, 1988; Zacks & Hasher, 1997).

3.1 The Interruption-Stress-Performance Relationship

When applying the person-environment fit perspective to the study of interruptions, one can deduce that interruptions create person-environment misfit, reflected in an increase in perceived mental workload (e.g., French et al., 1982). This perception, in turn, raises stress, which ultimately reduces task performance (Warburton, 1979). Further analysis of the person-environment fit theory follows, along with the hypotheses formalizing our core model.

Interruptions may affect perceived mental workload through their impact on the working memory capacity available for computer-based tasks. Specifically, because people have limited storage capacity in working memory (Dumas & Hartman, 2008), interrupting stimuli can dramatically reduce the capacity available for completing a task. This cognitive situation can be thought of as a zero-sum game: the resources available for a task are reduced by those allocated to the processing of interrupting stimuli (Hasher & Zacks, 1988). Thus, the more interruptions processed per unit time (i.e., the higher the frequency of interruptions), the fewer resources available for task-related information processing (Warburton, 1979; Hasher & Zacks, 1988). Yet, the task-related resource demands remain unaffected since the task itself does not change,[3] implying that interruptions shift the *relative balance* between available and required working memory resources, increasing perceived mental workload.[4] Thus:

H1: The frequency of interruptions is positively related to perceived mental workload.

The perception of an increase in mental workload is strongly associated with stress (Hart & Staveland, 1988). Based on person-environment fit theory, high levels of perceived mental workload lead to stress because they reflect insufficient resource supplies (Van Harrison, 1985), thereby signaling to workers that they are incapable of meeting the demands of their primary responsibilities and tasks (Warburton, 1979). This feeling of incapability generates a *feeling of being threatened* (Lazarus, 1999). The latter feeling of being threatened is an expectation of future harm—such as losing one's job, status within a community, or self-respect—and, therefore, immediately results in stress (Van Harrison, 1985).[5] Since computer-based tasks place especially high mental demands on individuals due to increased task complexity, work pace, and uncertainty (Birdi & Zapf, 1997), mental workload is likely to be an especially important stressor in computer-mediated (or computerized) work environments. Hence:

H2: Perceived mental workload is positively related to individual stress.

Stress has negative consequences (French et al., 1982). One important organizational consequence of job stress is a reduction in task performance (Beehr, 1995). As individuals experience stress, they devote a large amount of their limited energy to coping with this negative feeling rather than working, thus performing at a lower level (Lord & Kanfer, 2002). Stress may further result in reduced performance because people often attempt to escape from situations perceived as unfavorable (Chang et al., 2009; Lang et al., 2007). This analysis is supported by two recent studies (Chilton et al., 2005; Tarafdar et al., 2007), which found that stress and performance on computer-based tasks may be negatively correlated.[6] Thus:

H3: Individual stress is negatively related to task performance.

3.2 Age-Related Manifestations

Concerning *concentration* as an age-related manifestation, our research is the first that uses the inhibitory deficit theory of cognitive aging (Hasher & Zacks, 1988) to advance understanding of age-related impacts on IS phenomena. Based on the finding that older adults have far more information stored in working memory than younger adults, this theory holds that the inhibition mechanism consisting of access and deletion functions is impaired in older

[3] For example, an accountant having to prepare a balance sheet in SAP R/3® by the end of a fiscal year will have to prepare the same balance sheet in the same time frame irrespective of the frequency of interruptions.

[4] As indicated in the literature review, the person-environment fit perspective conceptualizes fit or misfit as a function of the *relative balance* between environmental demands per unit time or demand frequency (e.g., the frequency with which interruptions occur) and a person's mental resources (e.g., deciding, calculating, remembering) available for responding to these demands (Lazarus, 1999).

[5] While mental workload perceptions may have a curvilinear relationship with individual stress, we focus on the stress resulting from high workload on the grounds of parsimony. More specifically, the extant literature consistently indicates that excess resource demands give rise to stress (see McGrath, 1976, for an exception), while it is inconclusive on the role of excess resource supplies (Edwards ,1996). Given this inconclusiveness, proposing a curvilinear relationship may be inefficient. This proposition would reduce the parsimony of the model without being likely to increase its predictive power and the guidance it can provide to managers. In this research, post hoc analyses examining the curvilinear nature of the relationship between mental workload perceptions and individual stress supported this conclusion. Mental workload did not have a quadratic relationship with stress ($F(1,116) = 1.156$, $p > 0.05$).

[6] Individual stress may potentially have a curvilinear relationship with task performance, where the eustress associated with medium arousal may result in high performance because meeting challenges successfully is a source of pride and self-esteem. However, on the grounds of parsimony, we focus on the performance decrements resulting from experiences of distress associated with high arousal. Specifically, although some (e.g., Beehr, 1995) hold that arousal may predict task performance through an inverted, U-shaped curve, others found strong support for a linear relationship (Chang et al., 2009; Chilton et al., 2005; Lang et al., 2007; Tarafdar et al., 2007). In this study, post hoc analyses examining the curvilinear nature of the relationship between stress and performance supported the latter. Stress did not have a quadratic relationship with task performance ($F(1,119) = 0.000$, $p > 0.05$).

adults such that they are less able to ignore interrupting stimuli in the environment. This age-impact can be explained neurobiologically through the anatomical changes occurring in the frontal lobe, the crucial brain component for the holistic organization of all intellectual activity (Luria, 1973) that houses the inhibitory system (Jurado & Rosselli 2007). As people age, the frontal lobe's connections with other brain areas change and the frontal lobe shrinks, resulting in an inhibitory deficit (Jurado & Rosselli 2007). Thus, in older people, interrupting stimuli are more likely to gain access to working memory (access function) and to remain there (deletion function), continuously keeping the amount of mental resources available for the task at hand at a lower level than in younger adults (Zacks & Hasher 1997). A primary theory of aging, the inhibitory deficit theory has been widely confirmed in *experimental research* (e.g., Darowski et al., 2008; Hasher et al., 1991; Kim et al., 2007).

Combined with the person-environment fit theory, the Inhibitory Deficit Theory implies that effective inhibition may prevent interruptions from tilting the *relative balance* between the resources available and required for computer-based tasks over (i.e., effective inhibition may prevent interruptions from entering working memory and creating person-environment misfit and may, therefore, weaken the link between the frequency of interruptions and mental workload). Yet since older compared to younger users have lower levels of inhibition, older workers may benefit to a lesser extent from this mechanism's moderating impact. Hence:

H4: Inhibitory effectiveness moderates the effect of the frequency of interruptions on perceived mental workload so that the effect is weaker for higher levels of inhibitory effectiveness.

H5: Older compared to younger people have lower levels of inhibitory effectiveness.

Concerning *competence*, the behavioral performances of novices tend to be slow and effortful, whereas performances of experienced people tend to be fast and effortless since experience impacts the capacity of working memory (Strayer & Drews, 2007). Cognitive load theory (Sweller, 1994) explains this impact: as individuals gain experience with a task, the schemata in working memory that link related pieces of information become automated so that fewer mental resources are needed to complete the task. Hence, experienced people can more effectively manage competing resource demands (Liu et al., 2004) and may have more resources to spare for the processing of interruptions than those with less experience.

Since older people were educated when ICT was less complex, their mental models of how it works (i.e., mental representations of the structure, features, and usage characteristics of technology) may be insufficient for or may even interfere with effective interactions with modern ICTs (Ziefle & Bay, 2005). Given the rapidly changing, evolving nature of ICTs (Benbasat & Zmud, 1999), this situation is likely to continue, implying that older adults' mental models of how technology works may continue to be grounded in the past and, hence, outdated and incongruent with later technological developments (Ziefle & Bay, 2005). As a result of this incompatibility, older people should be less likely to gain relevant computer experience than younger people (Czaja et al., 2006). In sum, relevant computer experience may prevent interruptions by tilting the *relative balance* between the resources available and required for computer-based tasks, since people with more experience should have more resources to spare for the processing of interruptions. Yet, older compared to younger people may have less relevant computer experience (Tams, 2017), implying that they may benefit to a lesser extent from this mechanism's moderating impact. Thus:

H6: Computer experience moderates the effect of the frequency of interruptions on perceived mental workload so that the effect is weaker for higher levels of computer experience.

H7: Older compared to younger people have lower levels of computer experience.

People differ in their tendency to experience threat and anxiety as stress emotions on the basis of their *confidence* in themselves, referred to as self-efficacy (Bandura 1982; Lazarus 1999). Those with high self-efficacy believe in their ability to mobilize the cognitive resources and courses of action necessary to complete a task (Bandura, 1986; 1989). They visualize success scenarios and are optimistic; such feelings directly counter potential sensations of threat and anxiety (Bandura, 1997; Folkman & Lazarus, 1984). As a result, task demands present less of a struggle, and threat and anxiety as stress emotions are less likely to occur and will be weaker (Bandura 1997; Lazarus 1999). By contrast, people with low self-efficacy are more likely to visualize failure scenarios in stressful situations and to dwell on their personal deficiencies and the adverse consequences of failure (Bandura 1989). Consistent with this analysis, recent research reports that people with higher self-efficacy show less stress in the face of high task demands such as work overload (e.g., Nauta et al., 2010). Hence, computer self-efficacy (CSE) may be effective in helping people cope with such stressors like mental workload when performing computer-based tasks. In support of this logic, CSE has been found to correlate negatively with computer anxiety (Thatcher & Perrewe, 2002) and with such technological stressors as technological complexity (Ragu-Nathan et al., 2008).

However, past research suggests that age may be an important determinant of CSE (Marakas et al., 1998) since (1) older people suffer cognitive decline (Hasher & Zacks 1988), (2) older people adjust their self-efficacy beliefs as their cognitive abilities decline (Bandura 1994), and (3) computer-based tasks are particularly cognitively demanding (Birdi & Zapf, 1997). These conditions suggest that CSE declines as people age, particularly in the many OECD countries that celebrate youth, making age an important factor in self-evaluation (Bandura 1986). This potential age-impact is likely to continue into the future since cognitive decline, as an important factor in self-efficacy judgments, is an inherent aspect of biological aging (Jurado & Rosselli 2007), and since computer-based tasks will continue to be cognitively demanding (Benbasat & Zmud 1999). Hence:

H8: Computer self-efficacy moderates the effect of perceived mental workload on individual stress so that the effect is weaker for higher levels of computer self-efficacy.

H9: Older compared to younger people have lower levels of computer self-efficacy.

Concerning *capture*, relatively salient stimuli on such visual devices as computer displays elicit strong attentional capture effects by appealing strongly to peoples' amplification mechanism (Houghton & Tipper, 1994). A primary aspect of salience is color code, which refers to the color in which stimuli appear (Wickens et al., 2004). Due to peoples' past experiences with systems such as traffic lights and dashboards, and because of the relatively rare use of reddish colors, research consistently finds red to be the most salient color (Wickens et al., 2004). Older adults may be more affected by reddishness due to stronger attentional amplification[7] (Fisk et al., 2009). Hence, interruptions appearing on the screen in a salient color like red should be more likely than less salient ones to enter working memory and tilt the *relative balance* between available and required resources, leading to higher levels of perceived mental workload, particularly for older people.[8] Thus:

H10: There will be a three-way interaction among the frequency of interruptions, their salience, and age in the prediction of perceived mental workload such that the salience of interruptions will positively moderate the relationship between the frequency of interruptions and perceived mental workload, and this positive moderation will be stronger for older compared to younger people.

4 Research Method

To test the research model, we conducted a laboratory experiment, closely controlling the variables to maximize internal validity (Cook & Campbell, 1979). Our focus was on internal validity due to the novelty of our constructs (especially inhibition, salience, and age conceptualized as a substantive variable rather than a control). In accordance with this focus on internal validity, the sample population was defined broadly, implying that all individuals potentially working with ICTs were eligible to participate. Consistent with prior research on technostress and cognitive aging (e.g., Darowski et al., 2008; Galluch et al., 2015; Hasher et al., 1991), we recruited students from a major university and older individuals from the local community to represent our two age groups.

4.1 Experimental Task

To test our model of technological stressors and age, we had to use an information processing task demanding substantial working memory resources and sustained attention. To this end, we identified relevant criteria based on past research (e.g., Strayer & Drews 2007; Washburn 2003). The criteria for task selection (detailed in the left column of Table B in Appendix B) mapped especially well onto game-like computerized tasks, which bridge age-related differences since they tend to attract participation across demographic boundaries such as age (Washburn 2003). Thus, game-like computerized tasks were particularly appropriate for our focus on maximizing internal validity, and they offer several additional benefits for experimental research (Washburn 2003) (for more details, please see Appendix B).

We considered three relevant game-like computerized tasks that had been used in past studies and that fell into at least one of three categories: information search, memory, and sustained attention. The three tasks were the information search task *Memory* (e.g., Washburn et al., 2007), the working memory task *Anagram* (Sagarin et al., 2003), and the sustained

[7] The literature is inconclusive as to why attentional amplification increases with age. However, there is some conceptual (e.g., Fisk et al., 2009) and empirical evidence (e.g., Pratt & Bellomo, 1999; Whiting et al., 2007) showing that attentional capture effects elicited by salient stimuli are stronger in older than in younger adults, implying stronger attentional amplification in older adults.

[8] Please note that we depicted age as moderating the influence of interruption salience rather than impacting it directly. We modeled the age-salience interaction in this way because—in contrast to the other mechanisms—salience is not a trait of the individual but a feature of the interruption. This nature of salience implies that it cannot be impacted by age because it is external to an individual.

attention task *Jumpers* (Dabbish & Kraut, 2008). We mapped these tasks' features onto the criteria for task selection to enable a formal comparison. We found that the information search task Memory was optimal as it met all seven criteria, while Anagram and Jumpers met only 71% of the criteria (please see Appendix B). Hence, we used the Memory task.

The information search task Memory focuses on information gathering in terms of identifying new information and refreshing old information (Schumann-Hengsteler 1996). More specifically, in the Memory task, subjects generally have to find matching pairs of symbols by flipping computer-generated cards. In the process, they have to memorize where the symbols they have seen are hidden. This computerized task generally starts with a 4 x 4 matrix of cards with a symbol on one side, with two cards having the same symbol. The cards are presented face down to a subject, who flips two cards for every trial (i.e., one move). If the two uncovered symbols are not identical, both cards are returned to their face-down position. Once the subject detects a matching pair of cards, they are left in a face-up position. The task generally ends once all eight matching pairs are uncovered (Schumann-Hengsteler 1996). To find all matching pairs under time pressure in this information search task, the subjects have to remember what symbols have been revealed and where they are positioned in the matrix.

The subjects who work on the task represent workers engaged in information processing (e.g., cognitive functions of working memory and recall). Like the information search task Memory, computer-based tasks in organizations place extensive information processing and working memory demands on people due to fast work pace, the complexity of the information involved in organizational computer-based tasks, and the uncertainty of technology (Bensaou & Earl, 1998; Birdi & Zapf, 1997; Leidner & Keyworth, 2006; Galbraith, 1974). As Czaja and Sharit (1993, p. 3) note, "Although computer technology reduces the physical demands of jobs, it increases the information-processing demands." In fact, information processing lies at the very heart of IT-related work (Gallivan et al., 2005; Bensaou & Earl, 1998) (for more details, please see Appendix B, Section entitled Relevance to the Workplace).

For scientific purposes, the information search task Memory can be modified to fit the context of a study by varying the nature of the pairs of symbols to be memorized (Washburn et al., 2007). To ensure that our task reflected the demands of real-world computer-based tasks, which place particularly high mental demands on people and often involve simple mathematics (Birdi & Zapf, 1997), our task used arithmetic so that the working memory demands were close to subjects' working memory capacity. More specifically, one card contained an integer, and the matching card contained a multiplication yielding this integer. For example, a matching pair could consist of one card with the symbol "48" and another with the symbol "12 * 4." The cards were drawn at random. The objective of this computerized task was to find as many matching pairs as possible within the allotted time. Once a matrix of cards was entirely uncovered, another one appeared automatically until the time frame was exhausted. To increase the relevance of the task for the participants and their involvement, we incentivized good task performance.[9]

While the participants were working on the task (see Appendix C), interruptions appeared on the computer screen within specific time intervals (e.g., every 10 seconds). To prevent confounding effects due to individual differences other than age, the subjects were instructed to ignore the interruptions (Theeuwes, 1991). Over the course of the task, interruptions appeared randomly at varied locations on the screen so that they would resemble the real-world. To further ensure that interruptions were as intrusive as those in the real-world, their content was meaningfully related to the Memory task. Each interruption contained an equation in the form of "48 + 48 = 96." To prevent confounding effects on performance, the contents of interruptions were irrelevant for the task. The interruptions were drawn at random.

The interruptions constituted the causal agent for stress effects based on their impacts on perceptions of person-environment fit. The information search task Memory was selected based on past research so that it did not, by itself, create stress (Schumann-Hengsteler 1996; Washburn 2003). The rules of the Memory task are simple and easily understood, and people find the task enjoyable and entertaining (Washburn et al. 2007). In effect, the task itself creates feelings of comfort and easiness (Washburn et al. 2007). Thus,

[9] Incentive mechanisms included a performance-based lottery and a participant ranking. The lottery featured three prizes (e.g., the Nintendo Wii), all of which were valuable and of interest to both age groups. Quantitative (Likert-type scales) and qualitative (interviews) methods were used to determine an appropriate set of prizes. The drawing of the prizes depended on participant performance in the information search task such that higher performance yielded a greater likelihood to win a prize (in terms of a greater number of lottery tickets). For the ranking, the participants were asked to provide counterfeit names (e.g., "Peter43"), which were subsequently used to compile a performance-based ranking that was sent to all participants upon completion of the study (Yi & Davis, 2003). Ranking the participants increased the competitive nature of the task and made participation more meaningful (i.e., participation became meaningful above and beyond the motivating nature of the Memory task).

the experiment generates technostress based on a technological manipulation, the interruption. As such, consistent with Orlikowski and Iacono (2001), the experiment employed the *tool view of the IT artifact*. More specifically, the experiment emphasized IT-enabled information processing, representing the form of the IT artifact that Orlikowski and Iacono (2001) conceptualized as *technology as an information processing tool*. Further, the experimental task was not only consistent with the criteria laid out for this study and prior research on cognitive functioning and aging (e.g., Washburn et al., 2007), but it was also consistent with prior IS research on cognition that also employed game-like computerized tasks (e.g., Dabbish & Kraut, 2008).[10] Additionally, the subjects performed the task in a completely computer-mediated environment, creating an appropriate context for studying technostress.

4.2 Experimental Design

Consistent with our theoretical model, the experimental design includes three factors (age, frequency of interruptions, and salience of interruptions), each involving two levels, resulting in six experimental selections and manipulations (see Table 3).

[10] Prior research has employed different types of game-like computerized tasks, such as game-like information search tasks (e.g., Dabbish & Kraut, 2008), economic tasks such as the trust game (e.g., Riedl et al., 2014), and variations of the classical "Jump and Run" game (e.g., Dabbish & Kraut, 2008).

Table 3. Experimental Selections and Manipulations

Factor	Factor type	Selection/Manipulation	Level
Age	Between	Younger individuals	1
		Older individuals	2
Frequency of T-M interruptions	Between	Lower frequency of T-M Interruptions	1
		Higher frequency of T-M Interruptions	2
Salience of T-M interruptions	Within	Lower salience of T-M Interruptions	1
		Higher salience of T-M Interruptions	2
T-M = Technology-mediated			

The six selections and manipulations were associated with a 2 x 2 x 2 mixed-model design. Age (younger and older) and the frequency of interruptions (lower and higher) were the between-subject variables. Within each *age group*, the participants were subdivided into those presented with a higher frequency of interruptions and those presented with a lower frequency. Within each of the resulting four groups, the subjects were presented with each of two conditions for the salience of interruptions (lower and higher), with the order of presentation counterbalanced across participants. Our design, thus, resulted in a total of eight experimental conditions (see Table 4).

Table 4. Experimental Conditions

Factor	Experimental Selection/Manipulation							
Age	Younger				Older			
Frequency of T-M interruptions	Lower		Higher		Lower		Higher	
Salience of T-M interruptions	Lower (1)	Higher (2)	Lower (3)	Higher (4)	Lower (5)	Higher (6)	Lower (7)	Higher (8)
T-M = technology-mediated Numbers in parentheses represent the identifiers assigned to the conditions								

The experiment was fully randomized, with random selection and assignment of the subjects to the eight experimental conditions (Cook & Campbell, 1979). We analyzed all eight conditions in a full-factorial design since employing a fractional factorial would have resulted in relevant interaction effects being confounded with main effects, precluding us from testing the three-way interaction corresponding to Hypothesis 10.

A power analysis was conducted using G*Power 3.1 (Faul et al., 2009). The following input parameters were specified: four groups (since each subject participated in two of eight conditions), a moderate effect size (f = 0.25), an α-level of 0.05, a desired power level of 0.80, and a correlation of 0 between the repeated measures (for reasons of conservatism). The results indicated that a sample size of 90 participants was adequate for this research.

4.2.1 Measures Pertaining to the Core Model of Technostress

The frequency of interruptions (i.e., the number of interruptions in a given time interval) was manipulated at two levels: lower and higher. This manipulation allowed us to examine the effect of interruption frequency on perceived mental workload due to high cognitive demands, the focus of this study. We employed interruptions appearing every 15 seconds as a manipulation of higher frequency and interruptions appearing every 90 seconds as a manipulation of lower frequency based on extensive pretesting as detailed farther below. Perceived mental workload refers to the perceived ratio of mental resources required to accomplish a task to those available (Wickens et al., 2004). Measures for mental workload perceptions should possess a number of properties, including diagnostic capabilities, reliability, and low intrusiveness (Eggemeier, 1988). The NASA Task Load Index (Hart & Staveland, 1988), a comprehensive measure for mental workload perceptions, has been shown to meet these criteria (Cao et al., 2009). Most importantly, the Task Load Index is not perceived as intrusive by subjects (Hart & Staveland 1988), allowing the researcher to isolate stress effects on the basis of interruptions. Thus, this study used the Task Load Index to measure mental workload perceptions (please see Appendix D).

Stress refers to the extent to which a person responds to a perceived misfit between the resources available for performing a task and the environmental resource demands (French et al., 1982; Lazarus, 1999). Stress was captured via a stress scale. The scale (see Appendix D) was an existing stress measure; we adapted a five-item scale from Galluch et al. (2015), Moore (2000), and Schaufeli et al. (1995) that asked the subjects how much stress they experienced in response to the task they had just performed.

Task performance refers to the extent to which a task output is effective in meeting task objectives (Burton-Jones & Straub 2006). Thus, we measured performance objectively as the number of matching pairs uncovered in the information search task Memory within the allotted time period.

4.2.2 Measures Pertaining to the Age-Related Manifestations

Below we discuss the age ranges of the younger and older participants, the Stroop task as a measure of inhibitory effectiveness, the perceptual scales for computer experience as well as computer self-efficacy, and the experimental manipulation of the salience of interruptions. In psychology and IS research, age effects have primarily been measured by comparing chronologically younger to older people (e.g., Morris et al., 2005; Zacks & Hasher, 1997). Consistent with such research and in an effort to maximize treatment variance, we defined as younger adults those between 18 and 25 years of age and as older those between 60 and 85 years. This operationalization of older age was also consistent with the fact that the population historically associated with retirement constitutes the fastest growing part of the workforce, with the number of workers older than 65 rising dramatically (U.S. Bureau of Labor Statistics, 2008). Additionally, various organizations, such as H&R Block, currently employ workers over 80 years of age in ICT-heavy positions, such as expert tax accounting (Accountantsdaily, 2016). The older sample in our study consisted of active, mentally alert individuals. None of them reported having a degenerative disease.

Inhibitory effectiveness refers to the extent to which a person can deliberately inhibit or down-regulate the processing of interruptions, preventing interrupting stimuli from entering working memory (Hasher & Zacks 1988). The most widely accepted test for inhibition is the Stroop color-word test (Stroop, 1935; Shilling et al., 2002). By presenting color names printed in nonconsistent ink colors, the task requires subjects to ignore attentionally compelling but unwanted signals. Participants must actively inhibit the printed names of colors, while selectively attending to the ink color in which the words are printed. To illustrate, a subject may have to name the ink color green for a word that reads "blue." Since most people have a natural tendency to read, they must inhibit this response to correctly name the ink color (Shilling et al., 2002). This objective test yields the Stroop effect, which is the actual measure. Specifically, the Stroop effect is the difference between response times with incongruent and congruent words. The Stroop color-word test has wide support for its measurement properties; its test-retest reliabilities range from 0.83 to 0.91 (Spreen & Strauss, 1998).

Computer experience refers to the extent to which people have been using computers over their lifetimes (Harrison & Rainer, 1992)[11]. We adapted a three-item

[11] Although it seems intuitively plausible that older people have more computer experience than younger, by definition, due to their more advanced age, we contend that this will not be the case for those individuals aged 65 and

scale for computer experience from prior research (Bozionelos 2004; Harrison & Rainer, 1992) (please see Appendix D). To enhance item objectivity, subjects rated their experience in terms of specific time intervals ranging from less than once a year to about every day (Igbaria et al., 1995). Following Churchill (1979), we also constructed a measure for experience with the information search task Memory (please see Appendix E).

Computer self-efficacy (CSE) refers to the extent to which individuals believe in their ability to successfully use a computer in support of work tasks (Compeau & Higgins, 1995). We used Compeau and Higgins' (1995) original 10-item measure to evaluate CSE (please see Appendix D). By applying the guidelines advanced by Marakas et al. (2007) and Churchill (1979), we also constructed a measure of self-efficacy for the information search task Memory (please see Appendix E).

The salience of interruptions refers to the extent to which an interruption "pops out" of the computer display (Huang & Pashler, 2005). Salience has three major operational facets: color codes, dynamism, and aural alerts (Strayer & Drews, 2007; Wickens et al. 2004). While color code refers to the color in which a stimulus appears in a visual scene, dynamism refers to the extent to which appearing objects are emphasized through flashing or movement, and aural alert refers to the extent to which an appearing object is accompanied by sound effects. Consistent with prior research (e.g., Luoma et al., 1997; Wickens et al., 2004) this study used color codes to operationalize salience (see Appendix C) because aural alerts may have confounded salience with hearing abilities, and interruption movement is less common in organizational settings. Also consistent with prior research, we used a red border around the interruptions as a manipulation of higher salience and a gray one as a manipulation of lower salience.[12]

4.2.3 Control Variables

We employed key contextual controls; the experimental room was organized to minimize extraneous distractions, and all participants went through the experimental procedure in the same laboratory room. We further controlled statistically for alternative explanations pertaining to perceived mental workload, individual stress, and task performance (please see Appendix F); the control variables were included as covariates in the analyses (Cohen et al., 2003; Tabachnik & Fidell, 2007).

4.3 Experimental Procedure

The experiment was extensively pretested to evaluate the manipulations. Verbal protocols were also used to assess respondents' reactions to the manipulations. Consistent with recent experimental IS research (e.g., Qiu & Benbasat, 2009), we employed the significant difference method using t-tests to identify valid manipulations. More specifically, when two instances of a manipulation were perceived as significantly different by the pretest participants, we concluded that the manipulation was valid, with the relatively lower instance constituting the "lower" manipulation and the relatively higher instance being the "higher" manipulation. We identified that interruptions appearing every 15 seconds was a valid manipulation of higher frequency for both age groups, while interruptions appearing every 90 seconds was a valid manipulation of lower frequency. We further found that a gray border around the interruptions was a valid manipulation of lower salience for both age groups, while a red one was a valid manipulation of higher salience. Illustrative findings from verbal protocols include: "Red interruptions were absolutely more noticeable" and "Gray blended in with the background." Moreover, we found that four interruptions at a time was an appropriate set size (i.e., interruption complexity or the number of simultaneously appearing interruptions) for this study and that a duration of six minutes was optimal before fatigue set in.

We also pretested the survey instrument. Alphas ranged from 0.81 to 0.97 and the average variance extracted (AVE) exceeded 0.50 for all constructs. Further, the square root of each construct's AVE was larger than the interconstruct correlations. Thus, the instrument was considered reliable and valid. Following the development of our instrument, we conducted a pilot study, simulating the full-scale experiment. We found that the experimental procedures operated as intended and that the means were generally in the expected directions, so we concluded that the experimental design had been finalized.

5 Analysis and Results

The experiment was conducted using a detailed protocol to ensure consistency. A total of 128 subjects participated in the main experiment, half younger and half older people. The average age of the younger subjects was 21; for the older subjects it was 71. Most participants were in very good health (mean of 3.8 on a 5-point scale). In addition, 47% of the participants

over, who constitute our focal interest group. These individuals have often not grown up with modern technology and, as a result, often think the computer age has passed them by (Brown, 2002; Czaja et al., 2006).

[12] Unlike inhibitory effectiveness, salience is *not a trait of the individual* but a feature of the interruption (Wickens et al., 2004). Hence, salience required an experimental manipulation rather than a Stroop-like task.

were male. Moreover, the average subject was college-educated (mean of 5.2 on an 8-point scale, SD of 1.03), engaged in mental activities several times a month (e.g., crossword puzzles, checkers) (mean of 3.25 on a 5-point scale, SD of 1.08), and engaged in physical activities several times a week (e.g., running, swimming) (mean of 3.72 on a 5-point scale, SD of 0.84). Construct correlations are provided in Table 5.

Table 5. Construct Correlations

	Variables	1	2	3	4	5	6	7	8	9
1	Interruption frequency	1.00								
2	Interruption salience	0.00	1.00							
3	Age	0.00	0.00	1.00						
4	Inhibitory deficit	0.00	0.00	0.21*	1.00					
5	Computer experience	-0.02	0.01	-0.52**	-0.29**	1.00				
6	Computer self-efficacy	-0.04	0.00	-0.61**	-0.14	0.61**	1.00			
7	Mental workload	0.17	0.12	-0.04	0.11	-0.10	-0.03	1.00		
8	Stress	0.08	0.02	0.12	0.29**	-0.26**	-0.23*	0.41**	1.00	
9	Task performance	-0.01	-0.02	-0.77**	-0.26**	0.52**	0.53**	0.01	-0.17	1.00
	Mean	0.50	0.50	0.50	67.82	4.51	4.72	54.34	2.35	40.16
	Standard deviation	0.50	0.50	0.50	131.32	0.94	1.36	13.77	0.97	15.72

Note: * and ** indicate significance at 0.05 and 0.01 levels, respectively. SPSS 15.0 was used for computation.

Once again, we conducted manipulation checks using t-tests to verify the validity of our frequency and color manipulations. For younger adults, the mean for lower perceived frequency was 3.21 (SD = 1.09) on a seven-point scale, while the mean for higher perceived frequency was 5.07 (SD = 0.80), a difference that was significant at the 0.001 level. For older adults, the mean for lower perceived frequency was 2.80 (SD = 0.93), while the mean for higher perceived frequency was 4.61 (SD = 1.31), a difference that was significant at the 0.001 level. A sample item is: “Interruptions appeared very frequently during the task” (please see Appendix E). For the salience manipulation, the mean for lower perceived salience for younger subjects was 4.00 (SD = 1.28) on a seven-point scale, while the mean for higher perceived salience was 4.83 (SD = 1.28). This difference was significant at the 0.001 level. The mean for lower perceived salience for older adults was 4.19 (SD = 1.11), while the mean for higher perceived salience was 4.60 (SD = 1.39). This difference was significant at the 0.01 level. A sample item is: “The interruptions seemed to ‘pop out’ of the computer display” (please see Appendix E). Based on these results, we concluded that the participants perceived our manipulations as intended across both age groups, implying that our manipulations were valid for both age groups. Furthermore, a psychometric analysis confirmed that our full survey instrument had good reliability and construct validity (please see Appendix G).[13]

Since common method bias can affect inferences of causality, we used both procedural and statistical remedies to control for method bias (Podsakoff et al., 2003). We embedded four procedural remedies: the use of multiple methods, the separation of the measurement of the independent and dependent variable pairs, the protection of respondent anonymity, and the reduction of evaluation apprehension. As a result of these precautions, common method bias was unlikely. In addition, to evaluate the significance of common method variance in our data, Harmon’s single factor test was performed through a factor analysis with maximum likelihood extraction and promax rotation [14] (Podsakoff et al., 2003). In this approach, all indicators are forced to fit on a single factor representing method effects. Common method variance is considered significant if the model fits the data (Podsakoff & Organ, 1986). In our data, a one-factor model showed a large misfit (c^2 [464] =

[13] SPSS® 18.0 was used to calculate all statistics for psychometric analysis and hypotheses testing.

[14] In contrast to the traditional orthogonal rotation methods (e.g., Varimax), oblique rotation methods such as promax allow the factors to be intercorrelated and are, therefore, generally preferred (Cohen et al., 2003; Tabachnick & Fidell, 2007).

2,420.40, $p < 0.001$). We further compared this measurement model to the full model and found that the 1-factor model fit the data worse (Δc^2 [145] = 1,918.82, $p < 0.001$), indicating that common method variance was not found.

Consistent with prior mixed between-within-subjects experimental IS research (e.g., Jiang & Benbasat, 2007; Roberts et al., 2005; Suh & Lee, 2005; Tam & Ho, 2006), repeated measures analysis of covariance (RM-ANCOVA) was used to test Hypotheses 1, 2, 3, 4, 6, 8, and 10 since all participants generated scores at each of two different experimental conditions in a 2 x 2 x 2 mixed-model design with one repeated measure (interruption salience) (Cohen et al., 2003)[15]. RM-ANCOVA effectively separates variation into between-subjects and within-subjects components and develops separate error terms for various segments of the within-subject effects (Cohen et al., 2003; Tabachnick & Fidell, 2007). RM-ANCOVA was particularly appropriate for our study because this study consisted mainly of experimental selections and manipulations as well as observed variables that were easily separable into three analytical steps (see Figure 3 in Appendix) (Kline, 2005). The relationships in each step were tested simultaneously rather than separately to appropriately estimate the standard errors (Cohen et al., 2003). Step 1 of our analysis included all tests pertaining to the link between interruption frequency and mental workload; accordingly, H1, H4, H5, H6, H7, and H10 were tested in this step. Step 2 included all tests relevant to the link between mental workload and stress; thus, H2, H8, and H9 were evaluated in this step. Step 3 included the tests pertaining to the link between stress and task performance; accordingly, H3 was tested within this step. Multivariate analysis of variance (MANOVA) was used to test Hypotheses 5, 7, and 9 comparing younger and older participants. Further, formal mediation analyses were conducted post hoc using the causal steps approach (Baron & Kenny, 1986). Continuous independent variables were mean-centered to ensure stable intercepts (Cohen et al., 2003), and our final sample size averaged 114 participants (each of which provided us with two data points).

The RM-ANCOVA conducted to test H1 showed a significant relationship in the positive direction as expected ($b = 8.098$, $F(1,93) = 8.904$, $p < 0.01$, $h_p^2 = 0.10$), suggesting that H1 was supported. For H2, the RM-ANCOVA showed a significant relationship in the positive direction as expected ($b = 0.006$, $F(1,116) = 14.846$, $p < 0.01$, $h_p^2 = 0.12$), suggesting that H2 was supported. For H3, the RM-ANCOVA showed a significant relationship in the negative direction as expected ($b = -3.226$, $F(1,117) = 5.577$, $p < 0.05$, $h_p^2 = 0.05$), suggesting that H3 was supported.

To test H4, we created a product term by specifying an interaction between interruption frequency and inhibition in the SPSS model. Inhibition was mean-centered to ensure a stable intercept (Cohen et al., 2003). The RM-ANCOVA showed a significant interaction in the positive direction as expected ($b = 0.064$, $F(1,93) = 4.532$, $p < 0.05$, $h_p^2 = 0.05$), implying that H4 was supported. A positive interaction was expected since the Stroop task evaluates subjects' inhibitory deficit, not their inhibitory effectiveness; larger values for the Stroop effect imply stronger inhibitory deficits. Following Cohen et al. (2003), the predicted values for mental workload for the frequency-inhibition interaction are plotted in Figure 4 (see Appendix). For H5, a MANOVA was conducted that showed a significant effect of age on inhibitory deficit ($F(1,118) = 7.980$, $p < 0.05$, $h_p^2 = 0.06$), indicating that H5 was supported. The mean for inhibitory deficit for older adults was 97.63 (SD = 171.08), while it was 42.41 (SD = 76.70) for younger adults. Hence, the proposed age-related manifestation referred to here as *concentration* was supported.

To test H6, a product term was created by specifying an interaction between interruption frequency and computer experience. Computer experience was mean-centered to ensure a stable intercept (Cohen et al., 2003). The RM-ANCOVA showed a significant interaction effect in the negative direction as expected ($b = -8.568$, $F(1,93) = 5.246$, $p < 0.05$, $h_p^2 = 0.06$), suggesting that H6 was supported. Interruption frequency had a larger impact on mental workload for people with low levels of computer experience than high. The predicted values for mental workload for the frequency–computer experience interaction are plotted in Figure 4 (see Appendix). To test H7, a MANOVA was conducted that showed a significant effect of age on computer experience ($F(1,118) = 48.200$, $p < 0.05$, $h_p^2 = 0.29$), supporting the proposed age-related manifestation referred to here as *competence*. The mean for computer experience for older adults was 4.04 (SD = 1.12), while it was 4.99 (SD = 0.06) for younger adults.

To test H8, a product term was created by specifying an interaction between mental workload and CSE. CSE was mean-centered to ensure a stable intercept (Cohen et al., 2003). The RM-ANCOVA showed a significant interaction in the negative direction as expected ($b = -0.003$, $F(1,116) = 4.801$, $p < 0.05$, $h_p^2 = 0.04$), supporting H8. The predicted values for stress for the mental workload–computer self-efficacy interaction are plotted in Figure 4 (see Appendix). For H9, a MANOVA was conducted that showed a significant effect of age on CSE ($F(1,118) = 68.650$, p

[15] Since salience had only two levels, the sphericity assumption was not relevant (Cohen et al., 2003).

< 0.05, $h_p^2 = 0.37$), indicating that H9 was supported. The mean for CSE for older people was 3.90 (SD = 1.33), while it was 5.52 (SD = 0.77) for younger people. Hence, the proposed age-related manifestation referred to here as *confidence* was supported.

The RM-ANCOVA conducted to test H10 did not show a three-way interaction ($F(1,98) = 3.081$, $p > 0.05$), indicating that H10 was not supported. Potential reasons for this finding are explored in the next section. For the post hoc assessment of the mediating role of perceived mental workload between interruption frequency and stress, we employed Baron and Kenny's (1986) causal steps method and full mediation was observed (please see Appendix H).[16] Concerning the mediating role of stress between mental workload and performance, full mediation was observed (please see Appendix H). Additionally, formal post hoc tests of mediated moderation were conducted for the mediating roles of inhibitory effectiveness, computer experience, and computer self-efficacy between age and the core model. These tests were performed using the generally agreed-upon mediated moderation procedure developed by Baron and Kenny (1986), who also initially coined the term *mediated moderation* (Mueller et al., 2005; Preacher et al., 2007). This procedure showed that the moderating effect of age on the link between interruption frequency and mental workload was explained by the moderating impacts of inhibitory effectiveness and computer experience (see Appendix H). It also showed that the moderating effect of age on the link between workload and stress was explained by the moderating impact of computer self-efficacy (see Appendix H). In summary (see Table 6), the research model was largely supported. The effect sizes excluding other factors (i.e., h_p^2) ranged from 4% to 12%, a range considered medium to large in repeated measures analysis (Cohen, 1988).

[16] We also tested for mediation using the Sobel test (Sobel 1982) and the bootstrapping procedure (Preacher & Hayes, 2004, 2008), which yielded results consistent with Baron and Kenny's (1986) causal steps method.

Table 6. Summary of the Support Found for the Research Hypotheses

Hypothesis number	Statement	Supported ?
1	The frequency of T-M interruptions is positively related to perceived mental workload.	✓
2	Perceived mental workload is positively related to individual stress.	✓
3	Individual stress is negatively related to task performance.	✓
4	Inhibitory effectiveness moderates the effect of the frequency of T-M interruptions on perceived mental workload so that the effect is weaker for higher levels of inhibitory effectiveness.	✓
5	Older compared to younger people have lower levels of inhibitory effectiveness.	✓
6	Computer experience moderates the effect of the frequency of T-M interruptions on perceived mental workload so that the effect is weaker for higher levels of computer experience.	✓
7	Older compared to younger people have lower levels of computer experience.	✓
8	Computer self-efficacy moderates the effect of perceived mental workload on individual stress so that the effect is weaker for higher levels of computer self-efficacy.	✓
9	Older compared to younger people have lower levels of computer self-efficacy.	✓
10	There will be a three-way interaction among the frequency of T-M interruptions, their salience, and age in the prediction of perceived mental workload such that the salience of T-M interruptions will positively moderate the relationship between the frequency of T-M interruptions and perceived mental workload, and this positive moderation will be stronger for older compared to younger people.	☒

6 Limitations

Like any research, this study has limitations that should be considered when interpreting our results. First, one could reasonably argue that the perceived measures of technological stressors that used in previous studies, for example, "I feel constant threat to my job security due to new technologies," already captured individual differences. Individual differences were captured in individuals' different responses concerning the perception of the stressor. Some respondents might have felt a threat to their job security from new technologies, whereas others might not have. This argument that individual differences were already captured in previous studies' perceived measures of technological stressors could limit the present study's contributions, especially because this research employed objective manipulations of technological stressors (interruptions). However, while past studies using perceived measures of technological stressors may have already captured individual differences such as age, they never disentangled the effects of these individual differences. Individual differences were captured implicitly in these measures and were not further examined. Our research makes the role of age explicit, by selecting different age groups and disentangling the effects of age on technostress.

Second, while our task had numerous elements that parallel organizational-IT use (please see Appendix B for more details), it may still have limited ecological validity (i.e., real-world resemblance) with respect to specific technologies such as SAP R/3, Microsoft Excel, or Microsoft SharePoint, since an information search task was used to simulate the mental demands and related conditions of organizational-IT use. Yet, although the task used in this research may not have a direct real-world counterpart, the study can still provide us with an understanding of real-world phenomena since the psychological processes uncovered here may also operate in the real world (Mook, 1983). For example, people are likely bounded by their working memory capacity, computer experience, and computer self-efficacy not merely in the laboratory but also in organizations since these traits characterize individuals regardless of the setting in which they act (Bandura, 1997). Prior research conducted in the field supports this notion (e.g., Compeau & Higgins 1995; Gallivan et al., 2005).

To maximize the relevancy of our results for real-world settings, we implemented different strategies in our research design. First, we used such incentive mechanisms as lotteries and participant rankings to help increase the relevance of the task for the participants and the participant involvement. Second, we selected the software application used in the study (i.e., the information search task Memory), the participants, and the measures to be consistent with much prior research in the areas of cognition, aging, and technostress (e.g., Basoglu & Fuller, 2007; Washburn et al., 2007; Zacks & Hasher, 1997). Finally, we selected the task based on its considerable relevancy to the workplace in terms of human cognition and workplace conditions (e.g., information processing, working memory, attention, time pressure, engaging nature) (please see Appendix B for more details).

Hence, although the present study did not employ specific organizational software, such as SAP R/3, as its task, its task did represent work enabled by IT that is—at a general level—typical of the work performed in organizational settings. As a result, this study may have substantial ecological validity with respect to the general use of ICTs in organizations,[17] implying that the findings of this study may well be applicable to various other environments, for example, hospital operating rooms (Ren et al., 2008).

Third, only one technological stressor, the interruption, was examined here. Thus, it is currently unclear how well the findings of this study may extend to other technological stressors such as constant connectivity or rapid technological change. Yet, although these stressors are distinct, they are also similar in important ways such as their relationship to cognition (Czaja et al., 2006; Ragu-Nathan et al., 2008). This similarity implies that future research examining whether our research model could be extended to these other stressors may well yield positive results. Additionally, this study relied on a single measure of stress, a Likert-type scale. Recent research suggests that physiological stress measures, such as changes in stress hormone levels, might be complementary to perceptual measures such as Likert-type scales (Tams, Hill, et al., 2014).

[17] As elaborated upon in Appendix B, the task employed in this study represents work enabled by IT that is—at a general level—typical of the work performed in organizational settings. This generality has the advantage that our findings may apply to a large variety of IT-related jobs in organizations rather than only to very specific kinds of software systems, such as SAP R/3, MS Excel, or MS SharePoint. For example, had this study employed such spreadsheet software as Excel as its task, the task may not have generalized to the use of, e.g., SAP R/3 or MS SharePoint, which operate differently in accordance with their different purposes and navigation systems. Further, lab experiments can be of substantial scientific value even if they lack ecological validity, particularly if the primary research objective is to test theoretical propositions as opposed to the magnitude of relationships in a specific target population (Berkowitz & Donnerstein, 1982). This research tested theoretical propositions.

Physiological measures could complete the prediction afforded by perceptual measures through the explanation of additional variance in a theoretically-related outcome. For example, Riedl et al. (2012) showed that computer breakdowns can generate elevations in the stress hormone cortisol. Galluch et al. (2015) provided evidence that technology-mediated interruptions can elevate certain stress hormones. More generally, Riedl (2013) pointed out that technostress research could benefit from the application of various physiological assessments, including hormone levels, blood pressure, heart rate variability, or skin conductance response. These ideas are consistent with current advances in NeuroIS research (Fischer & Riedl, 2015; Riedl & Léger, 2016; Riedl et al., 2014). Hence, a complementary application of perceptual and physiological measures would be desirable. Future research could evaluate stress using both perceptual and physiological measures so that a greater understanding of technostress' impacts can be achieved.

Finally, we did not find support for Hypothesis 10. A plausible explanation relates to color as a dimension of salience. Differences in the color of interruptions that appear on the screen may perhaps not be sufficient to elicit differential attentional capture effects across age groups. It is possible that other dimensions of salience, such as whether a message moves across the screen or appears with an aural alert, provoke stronger attentional capture effects and would show the anticipated pattern where color did not. While the literature on attentional capture (e.g., Strayer & Drews, 2007; Wickens et al., 2004) is silent on the issue of whether different dimensions of salience are differentially effective in capturing attention, exploring the effects of various dimensions seems to be a viable avenue. This exploration may further our understanding of the role of salient display features in technostress and of how salience interacts with age.

7 Implications for Research and Practice

To shed light on the role of age in technostress, this study opened three central black boxes. First, by using person-environment fit theory and research on cognition, *we have opened the black box linking interruptions and stress.* We propose working memory as an important facet of cognition involved and reveal perceived mental workload, a form of person-environment misfit, as the connector between interruptions and stress. Second, *we have opened the black box linking interruption-based technostress and organizational productivity*, revealing task performance as a likely connector. While organizational productivity was not included as an outcome variable in this study, the link between task performance and organizational productivity is established in the literature (Davis & Yi, 2004). More specifically, since an organization is composed of individuals who accomplish the work tasks, its productivity is a direct function of individual performance. Unpacking these two black boxes associated with the stress process was important to understand the mechanisms through which age impacts technostress and the organizational consequences of this impact. Ultimately, by finding technostress to increase with age across most of our theory-driven age-related manifestations (i.e., concentration, competence, and confidence), *we have clarified the directionality of the age effect in technostress and why it occurs* (this clarification manifests itself at two links in the causal sequence from interruptions to stress). In the process, we also lent further empirical support to the earlier tested hypothesis that interruptions can result in stress (e.g., Galluch et al., 2015). Table 7 summarizes the findings of this study in terms of the value they add to research on technostress.

Table 7. Value-Added Features of this Research

Findings and corresponding hypotheses	Theories used	State of knowledge before this research	Limit in state of knowledge
Perceived mental workload intervenes in the relationship between T-M interruptions and stress because of limits in the capacity of working memory. (H1 and H2)	Person-environment fit theory and selective attention theory	Human cognition plays an important intervening role in the link between T-M interruptions and such interruption outcomes as individual stress. For example, interruptions overload cognitive capacity and break peoples' concentration on a task	Past research has discussed the role of cognition in technostress generically and has not included a construct related to cognitive capacity, yielding limited insight on what facets of cognition are involved and what the exact mechanisms are that link T-M interruptions to stress and performance outcomes.
The stress responses elicited by T-M interruptions affect individual task performance directly and, through this effect, may perhaps indirectly impact organizational outcomes. (H3)	Person-environment fit theory	Prior research in the area of T-M interruptions has stressed the negative implications of these interruptions for organizational productivity.	Past research is unclear on how T-M interruptions impact organizational productivity; it has largely omitted the factors that could explain how T-M interruptions could manifest themselves in organizational outcomes.
Older adults benefit less than younger from the moderating impact of attentional inhibition on the technostress process due to differing levels of inhibitory effectiveness. (H4 and H5)	Inhibitory deficit theory of cognitive aging	Prior research in the area of technostress has converged on the idea that the concept of age has an important role to play in explaining individual differences in stress responses	Prior research in the area of technostress is unclear on whether the stress responses associated with technological stressors increase or decrease as people grow older and why such age effects should occur at all. As a result, recent technostress research (Tarafdar et al., 2007) has called for a reexamination of the role of age in technostress
Older adults benefit less than younger from the moderating impact of computer experience on the technostress process due to differing levels of computer experience. (H6 and H7)	Cognitive load theory		
Older adults benefit less than younger from the moderating impact of computer self-efficacy on the technostress process due to differing levels of computer self-efficacy. (H8 and H9)	Person-environment fit theory and social cognitive theory		
Individual differences play a key role in the technostress phenomenon as they contextualize it and bound the applicability of technostress theory. (Implicit)	Person-environment fit theory and individual difference-specific theories	Individual differences were primarily considered as control variables with linear effects	Prior research has not examined whether technostress effects depend on individual differences (i.e., moderation effects showing for whom technostress crystallizes)

Table 7 (cont.). Value-Added Features of this Research

Findings and corresponding hypotheses	Value added	Practical implications	References
Perceived mental workload intervenes in the relationship between T-M interruptions and stress because of limits in the capacity of working memory. (H1 and H2)	A theory-driven explanation of what cognitive resources are overloaded and how and why they are overloaded, explaining how and why T-M interruptions result in stress.	Managers must consider limitations in the capacity of working memory; e.g., they could design jobs so that workers do not depend on a multitude of ICTs that constantly beep and buzz, thus helping them work within the boundaries of their working memory and fostering feelings of person-environment fit.	Basoglu & Fuller, 2007; Ren et al., 2008, Spira, 2005
The stress responses elicited by T-M interruptions affect individual task performance directly and, through this effect, may perhaps indirectly impact organizational outcomes. (H3)	A theory-driven explanation of how and why T-M interruptions can potentially affect organizational productivity.	Managers must be aware of the "dark side" of interrupting ICTs for task performance and should offer support—e.g., performance-related mentoring, feedback, and coaching.	Basoglu & Fuller, 2007; Ren et al., 2008; Spira, 2005
Older adults benefit less than younger from the moderating impact of attentional inhibition on the technostress process due to differing levels of inhibitory effectiveness. (H4 and H5)	Theory-driven explanations of the directionality of the age effect as well as why it occurs.	Systems designers should design systems for older workers around the principle of predictability of spatial location.*	Czaja et al., 1998; Hasher & Zacks, 1988; Ragu-Nathan et al., 2008
Older adults benefit less than younger adults from the moderating impact of computer experience on the technostress process due to differing levels of computer experience. (H6 and H7)		Managers and systems designers should help older adults increase computer experience through means such as training and by involving them in systems development.	Czaja et al., 1998, 2006; Sweller, 1994; Tarafdar et al., 2007; Ziefle & Bay, 2005
Older adults benefit less than younger adults from the moderating impact of computer self-efficacy on the technostress process due to differing levels of computer self-efficacy. (H8 and H9)		Managers should help increase computer self-efficacy in older adults through such means as training, situational support, and high quality feedback.	Bandura, 1982; Lazarus, 1999; Marakas et al., 1998; Ragu-Nathan et al., 2008
Individual differences play a key role in the technostress phenomenon as they contextualize it and bound the applicability of technostress theory. (implicit)	A more sophisticated understanding of whom technostress applies to, which thus helps technostress research progress toward greater specificity.	Managers may need to develop a sensitivity for the importance of individual differences for the effective use of ICTs; in particular, they may need to consider individual differences in interruption-related workplace design.	Ragu-Nathan et al., 2008; Tarafdar et al., 2007, 2010; Tu et al., 2005; Weil & Rosen, 1997

*The principle of predictability of spatial location implies that different types of T-M interruptions should all appear in the same (i.e., fixed) location on the screen, rather than different locations, in order to offset lower levels of inhibitory effectiveness in older adults. This principle is explained further in the following body text.

To discuss what the current study implies for research on technostress in terms of the role of age, we place its findings in the broader nomological network of technostress. The dominant paradigm in this domain holds that (1) technological stressors have direct, linear effects on stress, and (2) such organizational interventions as social support directly reduce the presence of both technological stressors and stress (e.g., Ayyagari et al., 2011; Ragu-Nathan et al., 2008; Tarafdar et al., 2007; Wang et al., 2008). The current research extends this dominant perspective in several important ways.

First, this study extends prior work by advancing explicit theoretical arguments for the role of age instead of relying on stereotypical accounts. In so doing, we found consistent age impacts across several facets of cognitive aging. Where prior research often observed age-related differences in stress responses that ran counter to their expectations (e.g., Czaja et al., 1998), we found support for the majority of our age-related hypotheses. Where the age-related implications offered in pioneering past studies often contradicted one another (e.g., Ragu-Nathan et al., 2008; Tu et al., 2005), raising the question of whether older adults experience more or less technostress than younger adults, we found consistent evidence across the three age-related manifestations of concentration, competence, and confidence, indicating that older adults experience more technostress. This finding implies an improvement in the modeling and subsequent understanding of age impacts.

Second, we show that the role of age in technostress is more complex than commonly assumed. While pioneering prior research has often proposed a direct and linear effect of age on the technological stressor (e.g., Ragu-Nathan et al., 2008), we show that age impacts technostress in a largely nonlinear fashion through its influence on pertinent cognitive abilities (i.e., inhibitory control and computer experience) and beliefs (i.e., computer self-efficacy) that interact with the technology. In doing so, we show that age acts as a moderator, and we specify how and why age plays this role, rather than merely showing that it does. This specification implies that our research yields a deeper understanding of the role of age in technostress.

Third, by positioning adult age at different links in the causal sequence from the technological stressor to the stress response, we show that the role of age in the technostress phenomenon is multifaceted. Where important past technostress research modeled age as a direct antecedent to the technological stressor (e.g., Ragu-Nathan et al., 2008), we show that age does not stop at impacting this external source of stress. Instead, age-related impacts manifest themselves across the nomological network of technostress through age-related changes in concentration, competence, and confidence. Hence, we show that age-effects yield a large set of potential anchor points for organizational intervention strategies.

Since this study examined the consequences of technology use for individuals and, by extension, for organizations, it may be practically significant, especially given the changing landscape of technology. For example, with Web 2.0, online interactions gain further importance, implying that we have just seen the beginning of the infusion of interruptions into peoples' personal and work lives. Further, the internet protocol version six (IPv6) allows for a much larger number of devices and users on the internet, enabling a rise in peoples' dependence on a multitude of ICTs that constantly beep and buzz. In particular, detrimental impacts on health and performance may arise from the interaction of Web 2.0 and IPv6. For instance, motivated by Web 2.0 and enabled by IPv6, the social networking site Facebook launched a group and video messaging initiative, furthering the likelihood of interruptions. Hence, managers may be well-advised to address the potential threats to organizational productivity arising from interruptions by using the findings of this research. For example, managers could invest more heavily in computer training for older workers to address the adverse effects of interruptions on their health and performance. Computer training may be a particularly effective strategy since it can simultaneously increase computer experience (Tomporowski, 2003) and computer self-efficacy (Marakas et al., 1998), both of which were shown in this study to weaken the negative impacts of interruptions. However, older workers are less likely than their younger counterparts to participate in training initiatives because their pay-back period is shorter (OECD, 2011). This analysis suggests that managers might have to offer older workers greater incentives for participation, in the form of special rewards and recognitions, such as monetary compensation, travel rewards, a one-time cash bonus, or an extra personal day. Additionally, organizational policies and cultural norms requiring employees to respond instantly to new instant messages could be relaxed, allowing workers to finish their tasks before reading and responding to incoming messages.

We would like to emphasize that this research does not imply that older adults are less adequate employees than their younger counterparts. Instead, we hold that older adults have different skills and that job redesign could help organizations better leverage those skills. On the one hand, this research showed that older adults' greater vulnerability to interruptions resulted in lower task performance on a short six-minute task. On the other hand, older workers' greater susceptibility to interruptions may benefit them and their respective organizations in tasks of longer durations. Recent research has shown that initially distracting information can lead to superior long-term performance in older adults compared to younger people when the initially distracting information becomes relevant at a later time (Kim et al. 2007). In line with this notion, if managers would reassign older workers to technology-heavy positions that emphasize long-term performance instead of short-term performance, they might find that older workers are a highly valuable human resource even in today's technology-driven world.

Similar to managers, systems designers could assist older workers in handling interruptions more effectively. Designers need to improve the ease of use of their systems for older people, allowing them to develop greater competence regarding modern applications (Czaja et al., 2006). In line with our previous theorizing, such an improvement could increase older workers' mental capacity for the processing of interruptions, thus reducing their perceptions of stress when performing computer-based tasks. To this end, systems designers may need to involve older workers more often and earlier in the design process (Newell et al., 2006). Designers, who tend to be younger individuals, often assume a similarity with the user, an assumption that breaks down for older individuals. Designers are often unaware of the potential age gap. Involving older people earlier in the design process could help bridge this gap, ensuring that older people are not overwhelmed by the interrupting nature of technology.

For example, systems designers could design different types of interruptions in such a way that they all appear in the same (i.e., fixed) location on the screen as opposed to different locations. Research has shown that predictability of spatial location can offset the substantial disadvantage of older people in inhibiting attentional responses to interrupting stimuli (Carlson et al., 1995). For example, in the current version of Skype (i.e., 4.2.0.169), VoIP phone calls and instant messages, which are different types of interruptions, appear in different locations on the display. While VoIP phone calls appear in the center, instant messages appear in the task bar on the bottom of the screen. If Skype were redesigned such that both types appeared in the task bar, older individuals could be helped in inhibiting an immediate response to either interruption type since they could better predict where interruptions appear on the screen (Carlson et al., 1995; Tams & Hill, 2016). It deserves mentioning that our study results should not be used to encourage discrimination against older employees but to facilitate interventions that can increase the well-being and productivity of a graying workforce.

8 Future Research

To further help managers and older workers fight technostress and its organizational consequences, future research should investigate additional age-related manifestations not examined here. For example, as peoples' ability to learn and adapt to new situations (i.e., fluid intelligence) declines with age (Czaja et al., 2006), they should experience more difficulty learning about and adapting to new ICTs. This difficulty may decrease the willingness of older adults to try out any new technology (PIIT; Agarwal & Prasad 1998) since difficulty using a technology reduces intention to use it (Venkatesh et al., 2003). This analysis combined with evidence of PIIT's strong link to computer anxiety (Thatcher & Perrewe, 2002) suggests that future research should examine whether PIIT serves as an additional, important age-related manifestation in technostress.

Our results also imply that the dominant research paradigm of identifying relevant technological stressors, their effects, and organizational interventions, although important, is not sufficient by itself; it is also necessary to examine what differences exist across people that explain varying stress responses and how and why stress responses vary with these individual differences. In fact, consistent with Bacharach (1989), our results show that such an examination of the applicability of technostress effects is critical for the advancement of theory development and testing in this area, helping technostress research progress toward more detailed and specific explanations of for whom technostress matters. Only through such work can we help organizations allocate limited resources for intervention strategies to those who would benefit the most from them. Hence, future research should study the moderating impacts of such other concepts as gender or culture, further advancing understanding of for whom technostress crystallizes.

As regards the moderating impact of gender, recent research has shown that male users can exhibit higher levels of stress than women in cases of system breakdown during task execution (Riedl et al., 2013). Concerning the moderating impact of culture, one study examined technostress in Chinese employees, motivated by the idea that cultural values might impact the extent to which technological stressors create stress responses in employees (Tu et al., 2005). Prior research has also shown that organizational culture, especially a focus on innovation, can create technostress in employees (Wang et al., 2008). However, these examinations, while important pioneering works, did not advance understanding of the specific mechanisms at play; that is, the mechanisms that underlie individual differences in technostress responses. More research is needed that explains precisely how and why technologies' impacts on employees' stress responses depend on such factors as gender or culture.

Finally, future work could adopt a more comprehensive assessment of mental workload (also referred to as cognitive load). While the NASA Task Load Index is a comprehensive assessment method consisting of multiple dimensions, it is purely perceptual in nature. Physiological measures could also be employed to complement perceptual ones (Hill & Tams, 2017). Such measures could include oculometry—which measures the movements of the eye—and EEG technology, which assesses changes in brain activity. Regarding the former, an eye-tracker can be used to record changes in eye movements and pupil dilation. Generally, increasing pupil dilation, rather than decreasing dilation, indicates increases in workload. As to EEG technology, workload can be inferred on the basis of a change in the spectral power of EEG signals (Müller-Putz et al., 2015; Ortiz de Guinea et al., 2013). To this end, electrical activity along the scalp can be recorded, permitting the researcher to analyze changes in the theta and alpha bands and ultimately, to infer changes in cognitive load (Müller-Putz et al., 2015). The theta-band power at the Fz electrode position has been shown to increase with increasing workload, whereas the signals in the alpha-band have been found to decrease at Fz and Pz positions with increasing load (Müller-Putz et al., 2015).

9 Conclusion

Considering the graying of the workforce in conjunction with the proliferation of technology, it appears crucial for managers to develop a deeper understanding of the role of age in the technostress phenomenon. Although a few prior technostress studies included age in their models, they often engaged in limited age-related theoretical development, resulting in contradictory findings. This study used pertinent theories of stress and cognitive aging and followed the touch point–based approach to studying age effects in IS (Tams, Grover, & Thatcher, 2014). In doing so, this study suggested, and for the most part found, that age-related differences in technostress manifest themselves through the mechanisms of concentration, competence, confidence, and capture—the four Cs. The power of these four Cs to explain age-related impacts on technostress is likely to continue into the future, for three main reasons (Tams, Grover, & Thatcher, 2014).

To begin with, the workforce will continue to age. In fact, the OECD (2011) expects the number of young workers (29 and younger) to decline over the next several decades, while it expects the traditional retirement population (65 and older) to grow dramatically. At the same time, the nature of technology continues to evolve and change at a rapid rate (Benbasat & Zmud, 1999). As a result of this rapid evolution of technology, older workers' mental models of how technology works will continue to be grounded in the past, even for the next generations of older workers. Older individuals' mental models of how technology works will continue to be dated and to be incongruent with later technological developments. This conclusion holds especially true because technology training is usually received at a person's younger age (OECD 2011), when technologies are very different from those present at that person's older age. Overall, age differences will persist due to the dynamic nature of technology.

Finally, there is a large age gap between younger systems designers and older users (Hawthorn, 2007). This age gap is so substantial that it is likely to continue into the future. For example, systems designers in the United States tend to be very young compared to the rest of the economy; less than 2% are older than 65 (U.S. Bureau of Labor Statistics, 2010), perhaps because older peoples' dated mental models of how technology works makes it more difficult for them to design modern systems. Hence, technology will continue to be designed with limited regard for older users.

Together, these three trends in society and technology indicate that this study's findings will be relevant today and in the future. Recent research also indicates that age differences in exposure to technology will continue to be prevalent in the future; the phenomenon of aging and technology use is not a transitory one (Hill et al., 2008; Tams, Grover, & Thatcher, 2014).

Thus, we believe to have made an important step toward clarifying the role of age in technostress, and we hope that this study will lead to more work in this area to help older people like Laura Oldfellow (from our opening vignette) use technology more easily and effectively.

However, our findings should not be construed as encouraging discrimination against older workers or as encouraging any kind of stereotyping. Instead, they should be considered a means of facilitating the development of intervention strategies that can increase the well-being and productivity of a graying workforce. Ultimately, managerial interventions and technological developments are needed that offset the weaknesses and leverage the strengths of older workers to improve their well-being and work performance, ultimately increasing organizational productivity.

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Appendix: Figures

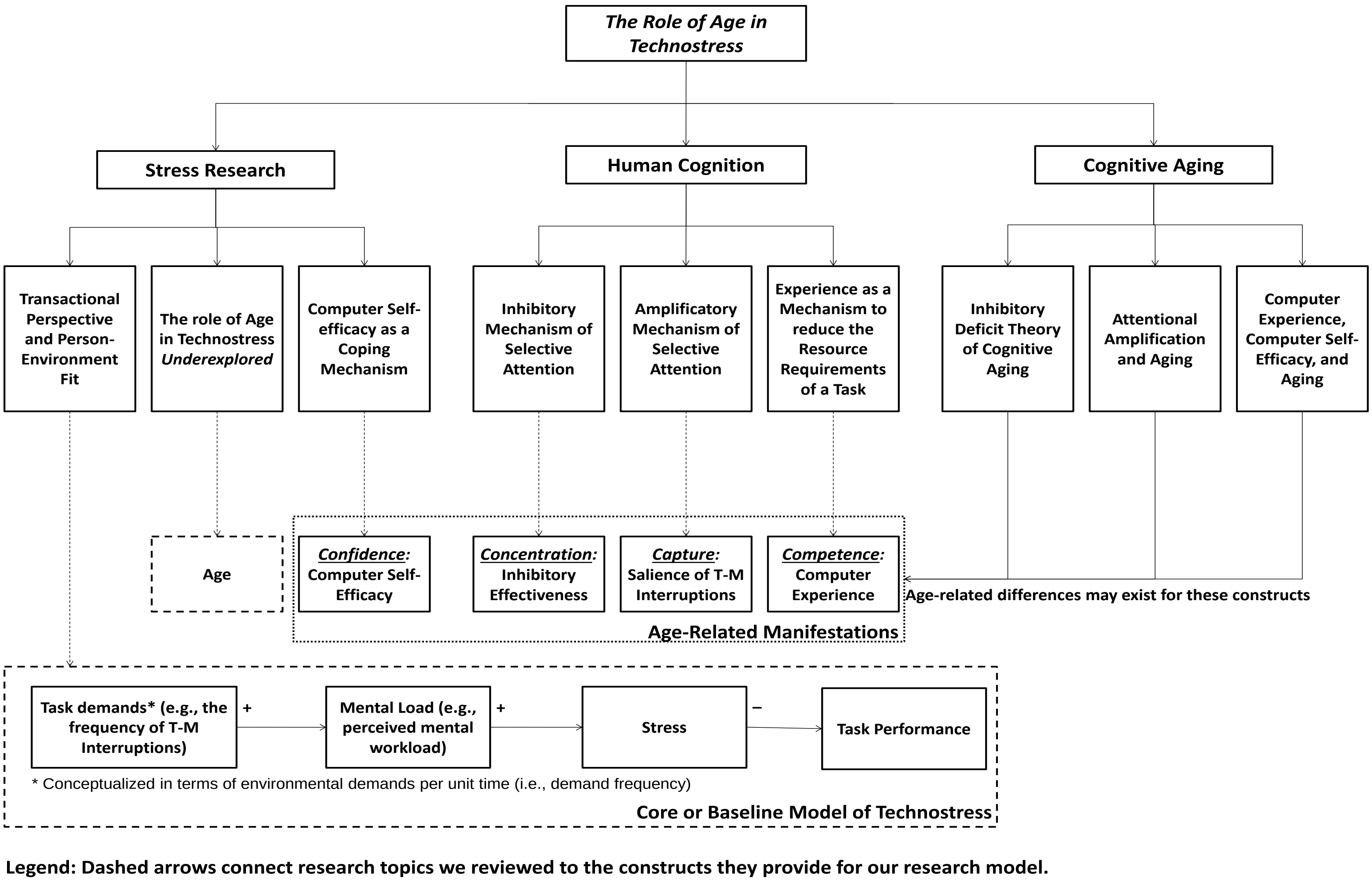


Figure 1. Illustration of how the Literature Review Frames a Model of the Role of Age in Technostress

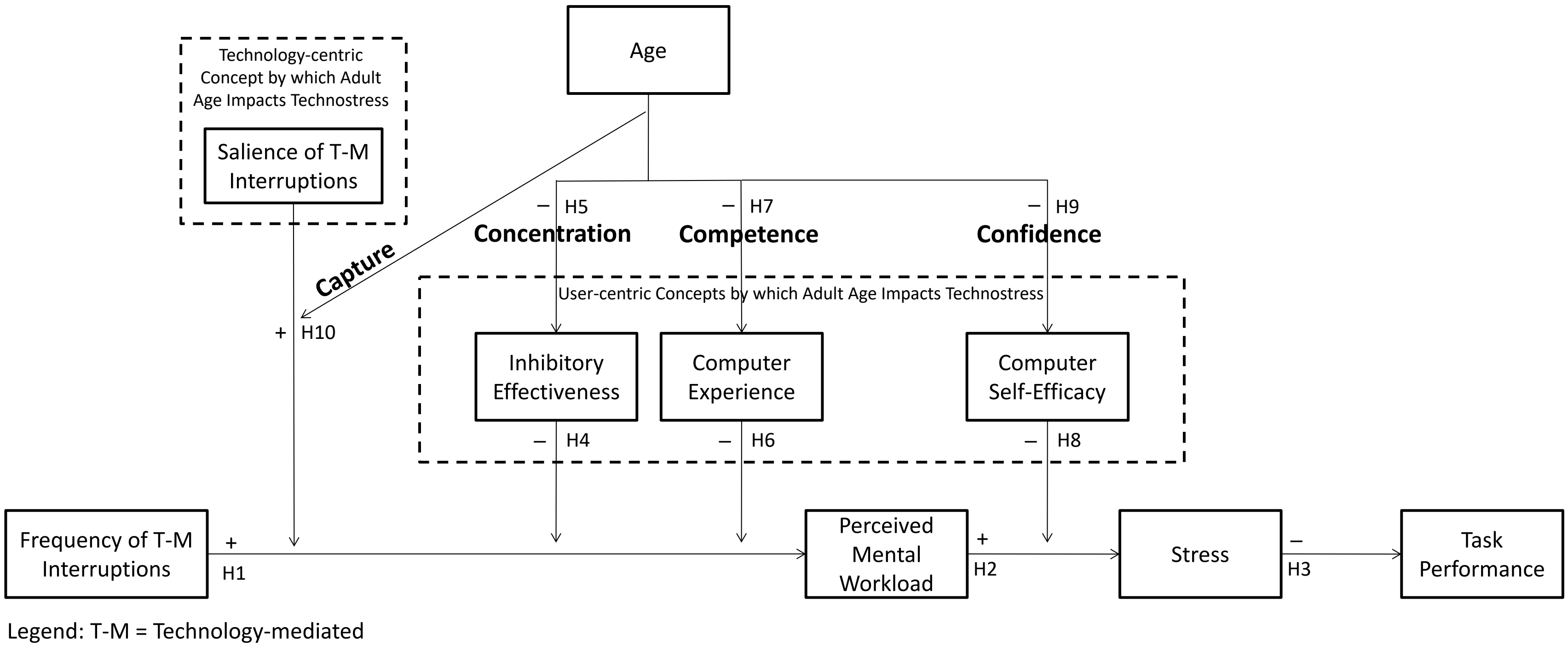
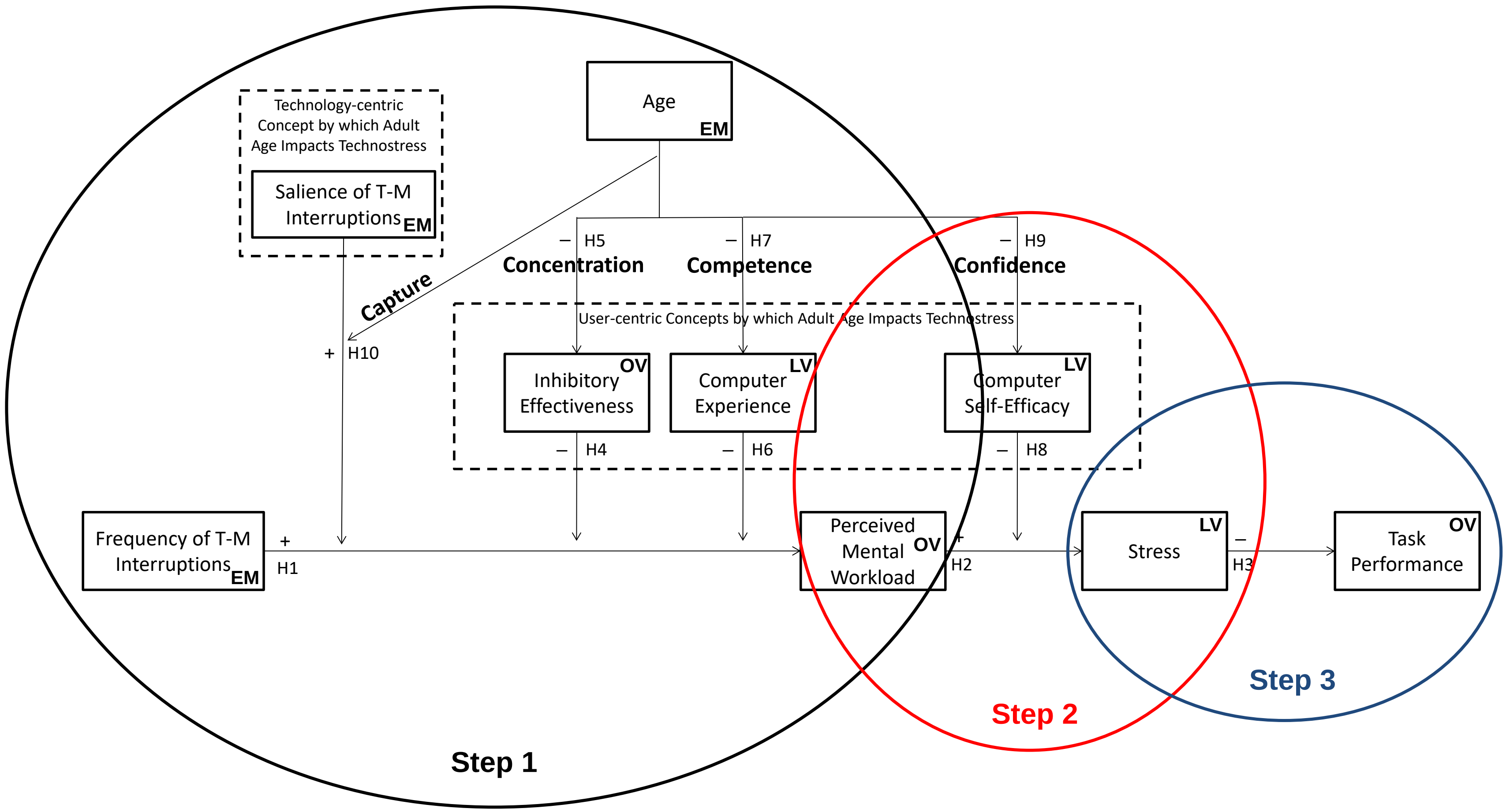


Figure 2. Research Model: Stress-Related Core and Age-Related Manifestations



Legend: T-M = Technology-mediated; EM = Experimental Manipulation or Selection; OV = Observed Variable; LV = Latent Variable

Figure 3. Steps Involved in Hypothesis Testing

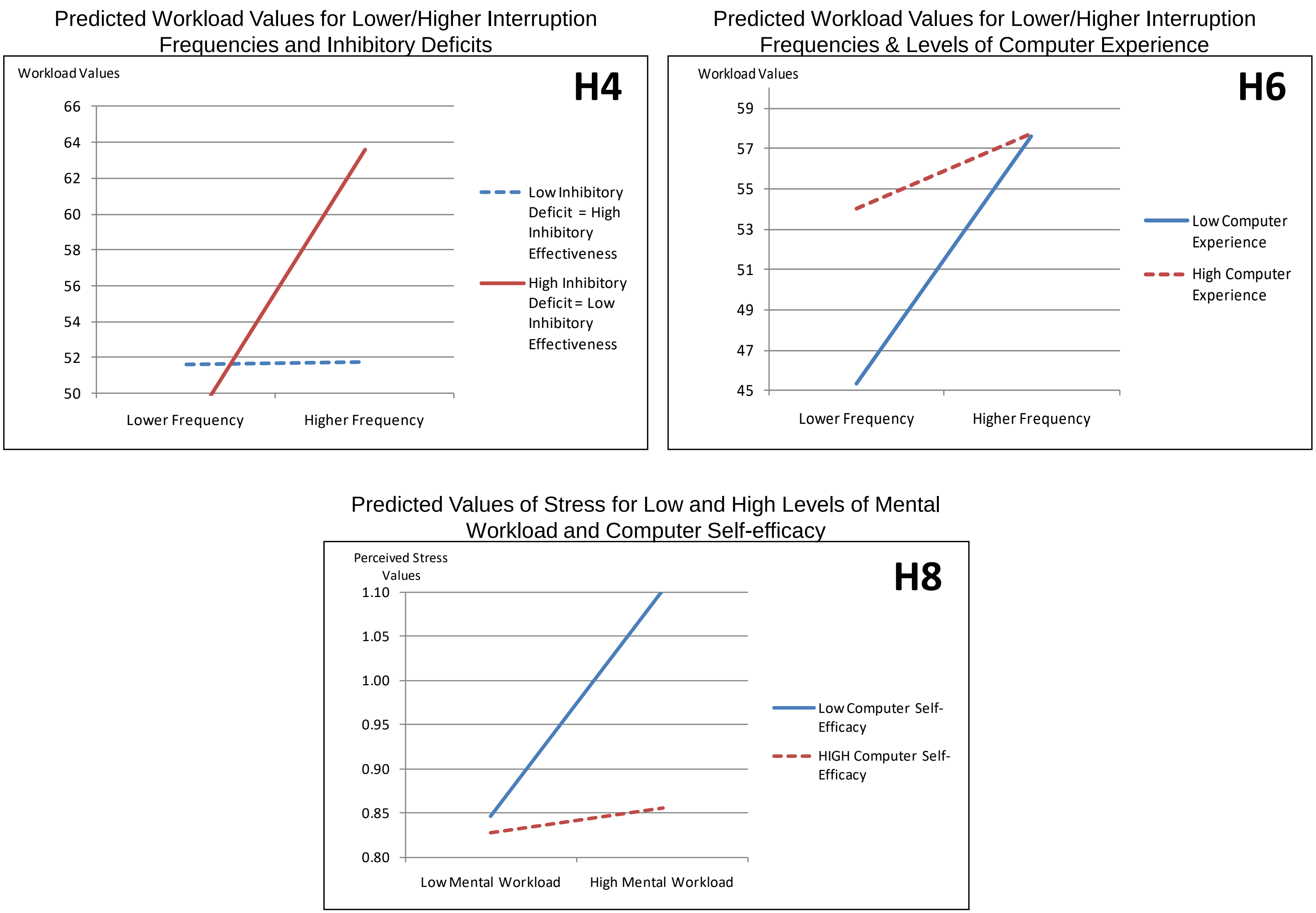


Figure 4. Predicted Values for Hypotheses 4, 6, and 8

Appendix A

A1. A Side Note on the Moderating Roles of Computer Experience and Computer Self- Efficacy

This study deviates to some extent from prior research in its treatment of computer experience and computer self-efficacy (CSE). More specifically, it treats these concepts as largely distinct, although they have sometimes been conceptually interrelated in the extant literature (e.g., Potosky 2002). While this approach implies that these concepts' treatment in this study may deviate from a part of the extant literature, we see two principal reasons for why their separate discussion is more appropriate for this particular research than their combined discussion: (1) the mixed empirical support in the literature for their relationship, along with (2) the distinct roles these two concepts assume in a model of technostress.

First, while CSE and computer experience have sometimes been conceptually interrelated in the extant literature (e.g., Potosky 2002), empirical analyses have resulted in mixed support for this relationship. Some studies reported positive correlations between the two concepts (e.g., Harrison & Rainer, 1992; Hasan & Ali, 2004; Laguna & Babcock, 2000), whereas others failed to find any support for their relationship (e.g., Beckers & Schmidt, 2003; Czaja et al., 2006; Potosky, 2002). For example, by subjecting survey data from 776 respondents to multiple regression analysis, Harrison and Rainer (1992) found a significant effect of computer experience on CSE. The authors measured experience in terms of the number of years of hands-on computer use and CSE though a 32-item Likert-type scale. Likewise, by relying on survey data from 151 respondents, Hasan and Ali (2004) found a positive correlation between computer experience and CSE, where experience was evaluated in terms of such applications as spreadsheet software and programming languages, and CSE was measured though nine items adapted from Compeau and Higgin's (1995) original scale. Similarly, by relying on correlation analysis on data from 141 respondents, Laguna and Babcock (2000) reported a significant positive relationship and concluded that computer experience predicts CSE. They evaluated experience though a composite measure consisting of the frequency of computer use and a global, perceptual experience measure. CSE was assessed through a 32-item Likert-type scale.

However, while the above examples support the idea of a relationship between computer experience and CSE, other studies failed to find such support. For example, Beckers and Schmidt (2003) examined the relationship between the breadth of experience in terms of the number of different applications used and CSE. In addition, they looked at the relationship between the hours spent on working with computers per week and CSE. Relying on data from 184 respondents, they found that both the correlation between the breadth of computer experience and CSE as well as the correlation between hours spent working on computers per week and CSE were nonsignificant. Potosky (2002) suggested that computer experience could serve as an avenue of enactive mastery and, thereby, impact CSE. Differences in prior experience could potentially enable people to look back at prior task accomplishments to different extents when making CSE judgments, thereby placing those with more experience at a judgmental advantage. Yet, by conducting an experiment with 56 participants and measuring both constructs using Likert-type scales, Potosky found their relationship to be nonsignificant. Similarly, in a study involving 1,204 survey respondents, Czaja et al., (2006) found that—despite comparable levels of computer experience—individuals frequently report significantly different levels of CSE.

Second, there is reason to believe that CSE and computer experience assume distinct roles in a model of technostress. More specifically, our literature review indicated that CSE may assume the role of a cognitive coping mechanism, allowing people to positively color the cognitive interpretation of stressful events. This implies that CSE may weaken the effect of person-environment misfit on stress. By contrast, computer experience may serve to reduce the requirements of computer-based tasks for cognitive resources, thereby weakening the effect of interruptions on person-environment misfit. Our results supported these roles, which arise from the concepts' relations to distinct facets of human cognition. While CSE relates to thinking processes and the cognitive representations of future events, computer experience relates to the cognitive resource requirements of computer-based tasks. As such, CSE—in contrast to computer experience—is concerned with what people think and how they interpret information, not with what information is being processed and how much mental capacity such processing requires (Bandura, 1986). It is for this reason that these concepts moderate different relationships in our model. Computer experience's and CSE's relationships to different facets of human cognition also imply that proposing moderating impacts of both these concepts on both relationships—interruptions-workload and workload-stress (i.e., everything is related to everything)—may be inefficient; such a proposition would reduce the parsimony of the model even though it would be unlikely to increase its predictive power and the guidance it can provide to managers.

Appendix B

Table B: Formal Comparison of the Memory, Anagram, and Jumper Tasks

Criterion		**How does the criterion represent real-world computer-based tasks?***	**Memory task**		**Anagram task**		**Jumpers task**	
#	**Description**		**CM**	**Explanation**	**CM**	**Explanation**	**CM**	**Explanation**
1	An extensive amount of information must be held in working memory and processed to make decisions (Darowski et al., 2008; Strayer & Drews, 2007; Wickens et al., 2004).	Real-world computer-based tasks place extensive information processing and memory demands on people due to a fast work pace, the complexity of the information involved in such tasks, and the uncertainty of technology (Bensaou & Earl, 1998; Birdi & Zapf, 1997; Leidner & Keyworth, 2006; Galbraith, 1974).	✓	Working memory demands can be adjusted by the investigator (Eskritt et al., 2001; Washburn et al., 2007).	✓	Known words have to be retrieved from long-term to working memory (Sagarin et al., 2003).	☒	No information held in working memory must be used to make decisions. Participants merely have to move a stretcher around (Dabbish & Kraut, 2008).
2	Focused attention must be sustained on the screen; thus, interruptions can be distracting (Spira, 2005; Strayer & Drews, 2007).	Real-world computer-based work generally demands sustained attention on a combination of both input and output devices (Agarwal & Karahanna 2000)	✓	The task is absorbing. Further, the time available can be adjusted by the investigator (Washburn, 2003; Washburn et al., 2007).	☒	The task requires focused attention only for a fraction of the time necessary to solve the anagram (Sagarin et al., 2003; 2005).	✓	The task is absorbing and requires the participants to sustain focused attention on the screen so that many jumpers can be saved.
3	There must be some time pressure to enhance sustained attention requirements and the relevance of interruptions (Spira, 2005; Strayer & Drews, 2007).	Time pressure is typical of real-world computer-based tasks because organizations allow individuals insufficient time to do their work (Ahituv et al., 1998; Swanson & Ramiller, 2004; Slone, 2007).	✓	The time available can be adjusted by the investigator (Washburn et al., 2007).	✓	The time available can be adjusted by the investigator (Sagarin et al., 2003; 2005).	✓	The jumpers have to be saved before reaching the ground, implying some time pressure.
4	The task needs to be engaging and absorbing to enhance intrinsic motivation and sustained attention, respectively (Washburn, 2003).	The use of contemporary information technologies in organizations tends to be both engaging and absorbing (Agarwal & Karahanna, 2000).	✓	The task is both engaging and absorbing (Washburn, 2003; Washburn et al., 2007).	✓	The task is engaging and absorbing (Sagarin et al., 2003; 2005).	✓	The task appears to be both engaging and absorbing.

Table B: Formal Comparison of the Memory, Anagram, and Jumper Tasks

5	No extra directions and no special knowledge should be required (Cook & Campbell, 1979)	This criterion is not necessarily reflected in real-world tasks, but it was necessary to conduct the study. Still, it can be expected that employees performing computer-based tasks know their jobs and technologies, especially since job postings tend to require some familiarity with ICTs.	✓	The task is simple and well-known by people of all ages (Eskritt et al., 2001; Schumann-Hengsteler, 1996; Washburn & Gulledge, 2002; Washburn et al., 2007).	✓	The task appears to be relatively simple. Special knowledge does not seem to be required.	✓	The task appears to be relatively simple. Special knowledge does not seem to be required.
6	The task needs to be suitable for both older and younger adults (Cook & Campbell, 1979)	Equal opportunity employment laws suggest that real-world tasks can be performed by both younger and older employees. More specifically, the Age Discrimination in Employment Act of 1967 protects applicants and employees 40 years of age or older from discrimination based on age in hiring, promotion, discharge, pay, fringe benefits, job training, classification, referral, and other aspects of employment (http://www.eeoc.gov).	✓	The task bridges age-related differences since it tends to attract participation across age groups, is well known across age groups, and is very simple (Washburn, 2003; Washburn & Gulledge, 1995).	?	Research examining the suitability of this task across age-groups is nascent. Hence, the question of whether this task is suitable across age-groups cannot be unambiguously answered.	?	Research examining the suitability of this task across age-groups is nascent. Hence, the question of whether this task is suitable across age-groups cannot be unambiguously answered.
7	The task ought to be demanding, but not stressful in and of itself (Cook & Campbell, 1979; Folkman & Lazarus, 1984; Lazarus, 1999).	Real-world computer-based tasks tend not to be stressful per se, but can be stressful due to such conditions as T-M interruptions and time pressures that surround them (Lazarus, 1999; Spira & Feintuch, 2005).	✓	Demands can be adjusted by the investigator (Eskritt et al., 2001; Washburn et al., 2007).	✓	Demands can be adjusted by the investigator (Sagarin et al., 2003; 2005).	✓	The number of jumpers can be adjusted by the researcher (Dabbish & Kraut, 2008).
Percentage of criteria met:			100%		71%		71%	

CM = criterion met

*Please note that we do not claim that the criteria represent the work of IS professionals. This study examines IT impacts on users, not the IT workforce. Thus, the criteria were selected consistent with prior research to enable the appropriate examination of age-related differences in response to technological stressors. As such, they are primarily based on and consistent with research on cognition, cognitive aging, stress, and experimental conduct. Yet, the criteria also represent work enabled by IT that is—at a general level—typical of the work performed in organizations. Hence, the findings from these tasks are generalizable.

B1. Rational for selecting the information search task Memory

B1.1 Consistency with Prior Research

The information search task Memory was carefully selected to satisfy the criteria laid out for this study and to be consistent with prior experimental IS research in the area of cognition (e.g., Dabbish & Kraut, 2008, who also employed a game-like computerized task). In addition, the task was carefully selected to be consistent with the literatures on cognitive functioning, aging, and age-related differences in cognitive functioning (e.g., Baker-Ward & Ornstein 1988; Schumann-Hengsteler 1996), arguably the most important criteria for this study. The information search task was particularly useful for bridging age-related differences since it is generally well-known by people of all ages (Washburn & Gulledge 2002), increasing the internal validity of the study. Consequently, the task was particularly appropriate for this study examining age-related differences in technostress. This conclusion holds particularly true since game-like computerized tasks such as the information search task Memory offer many benefits for experimental research (Washburn 2003; Washburn & Gulledge 1995). These tasks are intrinsically motivating and, hence, elicit motivated performance, and they provide continuity and context for responding (Washburn 2003). Perhaps most importantly for the research conducted here, game-like computerized tasks are, generally, very useful for bridging age-related differences in experimental settings since they tend to attract participation across demographic boundaries (Washburn, 2003).

B1.2 Relevance to the Workplace

The information search task Memory is relevant to the workplace. Overall, Memory is an explicit working memory task requiring individuals to maintain a large amount of information in working memory and use it to decide what card to flip next (Schumann-Hengsteler 1996; Sturm et al., 2004; Washburn et al., 2007). As such, the information search task employed in this study represents the tasks of IT users in organizations, tasks that are characterized by high demands for working memory capacity due to their inherent complexity (Adipat et al., 2011; Dimoka et al., 2012; Nah et al., 2011). Furthermore, Memory requires information processing (IP) over prolonged periods of time under extensive utilization of information held in working memory (Schumann-Hengsteler, 1996). This requirement is also typical of the tasks of IT users in organizations; in fact, IP lies at the heart of IT-related work (e.g., Gallivan et al., 2005; Bensaou & Earl 1998). These extensive IP demands of IT-related work are also the reason of why real-world computer-based tasks are classified as particularly mentally demanding (Birdi & Zapf 1997; Czaja & Sharit 1993). As Czaja and Sharit (1993) note (p. 3), "although computer technology reduces the physical demands of jobs, it increases the information-processing demands." These extensive IP demands of IT-related work can be explained with the complexity of the information that requires processing (e.g., manipulation and integration of data in Microsoft Excel or Access) and with increased work pace even for simple data entry tasks (Czaja & Sharit, 1993). They can also be explained with the concept of uncertainty; since IT is inherently uncertain (Leidner & Keyworth, 2006) and since uncertainty increases IP demands (Galbraith, 1974), IT-related work entails substantial IP requirements.

Moreover, the information search task Memory motivates sustained attention due to the task's absorbing nature (Washburn 2003; Washburn et al., 2007). Sustained attention is also typical of IT-related work, where attention has to be sustained on the combination of input and output devices (Agarwal & Karahanna, 2000). In fact, sustained attention represents an important flow experience in the context of ICTs, "where the individual's attention is limited to the narrow stimulus represented by the technology" (Agarwal & Karahanna, 2000, p. 668). Additionally, the information search task employed in this study engendered a substantial amount of time pressure, another aspect typical of real-world computer-based tasks because organizations often allow individuals insufficient time to do their work (Ahituv et al., 1998; Swanson & Ramiller, 2004; Slone, 2007). Furthermore, the task was engaging and absorbing (Washburn, 2003; Washburn et al., 2007), much like the use of contemporary ICTs in organizations, where "the individual's interaction with the technology extends beyond mere instrumentality to be pleasurable and enjoyable as an end in itself" (Agarwal & Karahanna, 2000, p. 668).

Overall, while the information search tack Memory is not equivalent to work in practice, it represents "engagement in a task" that is not dissimilar to any engagement a worker can have in the real-world work context. It is the disruption with the engagement that is being modeled through the experiment.

In summary, the task employed in this study represents work enabled by IT that is—at a general level—typical of the work performed in organizational settings. This generality has the advantage that our findings may apply to a large variety of IT-related jobs in organizations rather than only to very specific kinds of software systems, such as SAP R/3 OR Microsoft Excel OR Microsoft SharePoint. For example, had this study employed such spreadsheet software as Microsoft Excel as its task, the task may not have generalized to the use of, for instance, SAP R/3 or MS SharePoint, which operate differently in accordance with their different purposes and navigation systems.

Appendix C

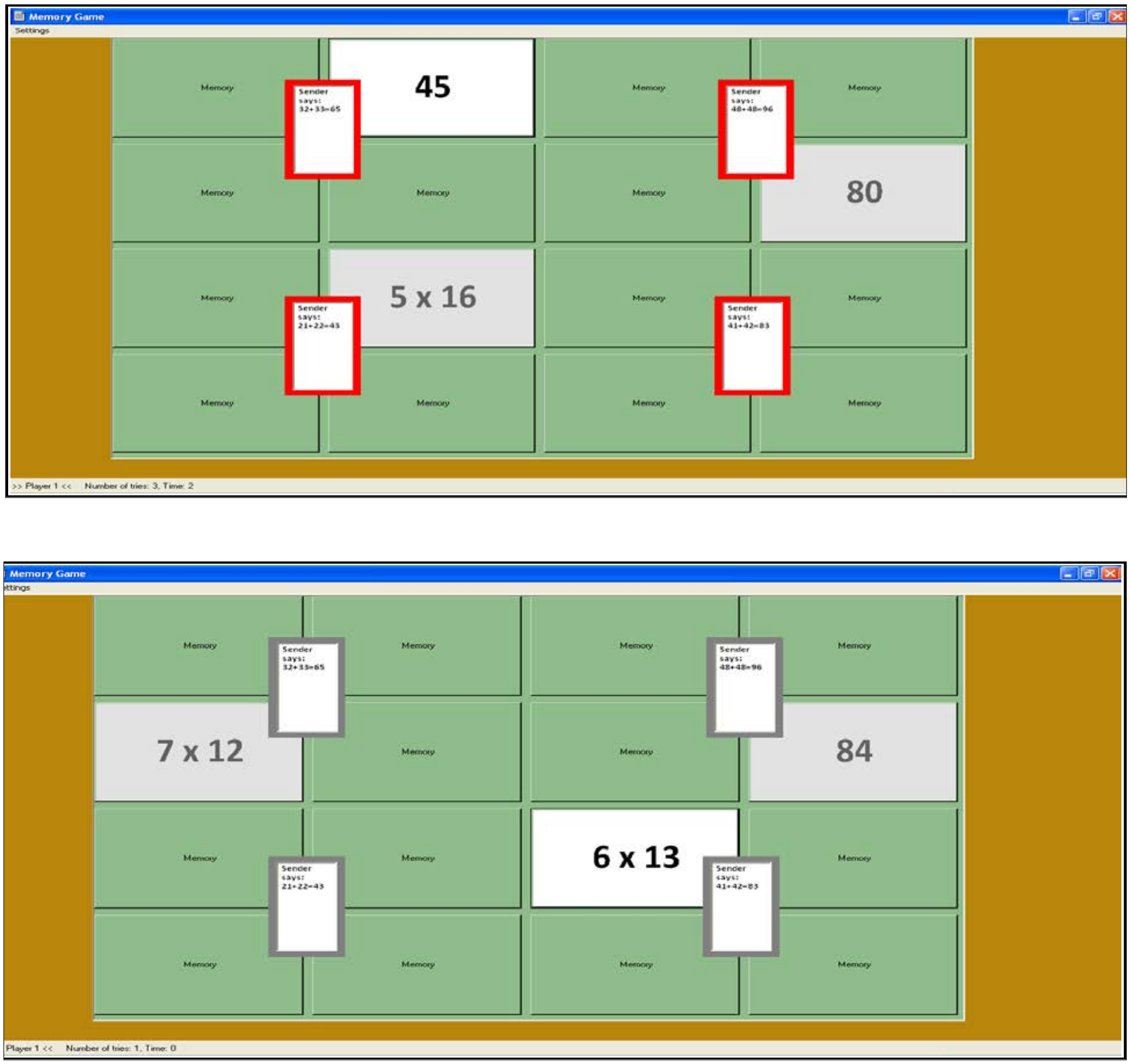


Figure C: Illustrative Interface with Higher (Top) and Lower (Bottom) Salience Manipulations

Appendix D

Table D: Measurement Items for Principal Perceptual Constructs

Construct	Measurement items	
	Item #	**Item**
Computer self-efficacy (Compeau & Higgins, 1995)	I could complete a job using the computer …	
	CSE1	...if there was no one around to tell me what to do as I go.
	CSE2	...if I had never used a package like it before.
	CSE3	...if I only had the software manuals for reference
	CSE4	...if I had seen someone else using it before trying it myself.
	CSE5	...if I could call someone for help if I got stuck.
	CSE6	...if someone else had helped me get started.
	CSE7	...if I had a lot of time to complete the job for which the software was provided.
	CSE8	...if I had just the built-in help facility for assistance.
	CSE9	...if someone showed me how to do it first.
	CSE10	...if I had used similar packages before this one to do the same job.
Computer experience (Bozionelos, 2004; Harrison & Rainer, 1992; Igbaria et al., 1995)	CE1	On average, how frequently do you use a computer for communicating with others (e.g., through email, instant messages, Facebook)
	CE2	On average, how frequently do you use Internet browsers such as FireFox, Internet Explorer and Google Chrome?
	CE3	Overall, how frequently do you use a computer?
Individual stress (Moore, 2000; Schaufeli et al., 1995)	Stress1	I felt emotionally drained from working on the memory task.
	Stress2	I felt used up due to the task demands.
	Stress3	I felt fatigued due to the task demands.
	Stress4	I felt burned out from working on the memory task.
	Stress5	I felt strain due to the task demands.
Perceived mental workload (NASA Task Load Index) (Cao et al., 2009; Hart & Staveland, 1988)	Click on each scale at the point that best indicates your experience of the task:	
	Mental demand	
	Physical demand	
	Temporal demand	
	Performance	
	Effort	
	Frustration	

Note: the TLX derives an overall assessment of perceived mental workload from a weighted average of ratings for the above subscales. This overall assessment yields a score between 0 and 100 (Cao et al., 2009; Hart & Staveland, 1988).

Appendix E

Table E: Measurement Items for Manipulation Checks and Control Variables

Construct	Measurement items	
	Item #	**Item**
Interruption frequency (Basoglu & Fuller, 2007; Warburton, 1979)	IF1	Interruptions appeared very frequently during the task.
	IF2	Numerous interruptions appeared over the course of the task.
Interruption salience (Houghton & Tipper, 1994; Strayer & Drews, 2007; Wickens et al., 2004)	IS1	The interruptions seemed to "pop out" of the computer display.
	IS2	The interruptions stood out from the other information on the display.
	IS3	Compared to other information on the screen, the interruptions had a very unique appearance.
	IS4	The interruptions were very effective in attracting my attention.
	IS5	The interruptions effectively grabbed my attention.
	IS6	The interruptions very effectively captured my attention.
	IS7	The interruptions were very noticeable.
	IS8	The interruptions were very eye-catching.
Experience with the information search task memory (Smith et al., 1999; 2007)	MemoryExp1	I have frequently played the memory game Concentration/Memory.
	MemoryExp2	I have played the memory game Concentration/Memory a lot.
	MemoryExp3	I have often played the memory game Concentration/Memory.
	MemoryExp4	I have experience with the memory game Concentration/Memory.
	MemoryExp5	On average, how frequently have you played the memory game Concentration/Memory?
Self-efficacy regarding the information search task memory (Marakas et al., 1998; 2007)	MemorySE1	I believe I have the ability to excel in the memory game Concentration/Memory.
	MemorySE2	I believe I have the ability to be successful at the memory game Concentration/Memory.
	MemorySE3	I believe I have the ability to describe how to play the memory game Concentration/Memory.
	MemorySE4	I believe I have the ability to perform well in the memory game Concentration/Memory.

Appendix F

Table F: Summary of Control Variables

Category	Control variable	Definition	Measure	Reference
Contextual	Location	Room in which the experiment was conducted	Same research laboratory for the entire study	Cook & Campbell, 1979
	Investigator	The person or persons who conducted the study	The same investigator conducted all experiments, always adhered to the same dress code and small talk topics, and sat quietly at all times.	Cook & Campbell, 1979
	Color-blindness	An individual's disability in distinguishing between different colors	An objective test of color-blindness supplemented by a binary self-report	Stroop, 1935
Mental workload	Gender	Male/Female	Binary variable equal to 0 if male and 1 otherwise	Czaja & Sharit, 1998
	Education	Extent to which people have been educated over their lifetimes	Eight-point scale ranging from "no formal education" to "doctoral degree."	Czaja & Sharit, 1998
	Working memory capacity	An individual's general capacity available for mental work	Computation span task	Salthouse & Babcock, 1991; Zacks & Hasher, 1997
	Short-term memory	An individual's retention over short periods of time	Remembering symbols over a 90-second period	McLeod et al., 1982
	Math accuracy	Extent to which an individual can accurately solve arithmetic problems	Operation span task	Salthouse & Babcock, 1991
	Memory experience	Extent to which an individual has played the memory game Memory over his or her lifetime	Five-item measure, e.g.: "I have frequently played the memory game Concentration/Memory."	Wierwille & Eggemeier, 1993
	Memory self-efficacy	Extent to which an individual believes in his or her ability to excel in the memory game Memory	Four-item measure, e.g.: "I believe I have the ability to excel in the memory game Concentration/Memory."	Wierwille & Eggemeier, 1993
Individual stress	Gender	Male/Female	Binary variable equal to 0 if male and 1 otherwise.	Ragu-Nathan et al., 2008
	Education	Extent to which people have been educated over their lifetimes	Eight-point scale ranging from "no formal education" to "doctoral degree"	Ragu-Nathan et al., 2008
	Physical activity	Extent to which an individual is physically active	One-item measure ranging from "every day" to "once a year or less"	Newson & Kemps, 2006; Wilson et al., 1999

Table F: Summary of Control Variables

Task performance	Gender	Male/Female	Binary variable equal to 0 if male and 1 otherwise	Ragu-Nathan et al., 2008
	Education	Extent to which people have been educated over their lifetimes	Eight-point scale ranging from "no formal education" to "doctoral degree"	Ragu-Nathan et al., 2008
	Mental activity	Extent to which an individual is mentally active	One-item measure ranging from "every day" to "once a year or less"	Newson & Kemps, 2006; Wilson et al., 1999
	Achievement orientation	Extent to which an individual strives for achievement	Seven-point scale ranging from "strongly disagree" to "strongly agree"	Elliot & Harackiewicz, 1994
	Motor functions	Differences in operational accuracy between computer mouse users	Prior experience using the mouse was required; no double-clicking operations were required by the tasks.	Charness et al., 2004
	Vision	Differences in vision between participants	Use of playing cards of large sizes and having subjects indicate whether they owned prescription glasses and were wearing them at test time.	Czaja et al., 2006

Appendix G

G1. Psychometric Testing of Perceptual Measures

Evaluating the quality of our survey instrument included estimating the reliability as well as the convergent and discriminant validity of the measurement items. SPSS® 18.0 was used to calculate all statistics, which were obtained through a factor analysis with maximum likelihood extraction and promax rotation. Six factors were specified for extraction since we analyzed items for six different constructs. Stress was separated into stress for red and gray interruptions since repeated measures designs require the data to be restructured so that variables that were measured repeatedly (stress in this case) have separate scales for the different categories of the repeated measure (red and gray in this case) (Tabachnick & Fidell, 2007). The internal consistency of a block of indicators is represented by Cronbach's coefficient alpha. Satisfactory values for this criterion exceed 0.70 (Nunnally 1978). All alphas exceeded this threshold (see Table G1), indicating satisfactory internal consistency reliability.

Table G1: Quality Criteria and Descriptions of Construct Measures

Construct	Number of items	AVE	AVE nonassociated items	Alpha	Mean	SD
Computer self-efficacy	10	0.70	0.004	0.96	4.72	1.36
Information search task memory experience	5	0.68	0.002	0.87	2.30	1.21
Perceptual stress for red interruptions	5	0.65	0.005	0.92	2.32	1.07
Perceptual stress for gray interruptions	5	0.63	0.003	0.91	2.29	1.05
Information search task memory self-efficacy	4	0.77	0.005	0.93	4.81	1.43
Computer experience	3	0.71	0.006	0.92	4.51	0.94
Note: AVE = average variance extracted						

The convergent validity of a construct is generally considered satisfactory when its AVE is at least 0.50 (Fornell & Larcker, 1981), whereas discriminant validity is considered adequate when the square root of the construct's AVE is larger than the interconstruct correlations (Chin, 1998). In our model, all AVE values exceeded 0.50 (please see Table G1), and the square root of each construct's AVE was higher than the correlations between that construct and all others (please see Table G2). These results indicated satisfactory construct validity. Moreover, the AVE value for nonassociated items, which quantifies the amount of variance a construct measure captures from the items it is not associated with relative to the amount due to measurement error, was less than 0.01 for each construct (please see Table G1). This result further confirmed construct validity (Fornell & Larcker, 1981).

Table G2. Interconstruct Correlations

Construct	CSE	MemoryExp	Stress.Red	Stress.Gray	MemorySE	CE
Computer self-efficacy (CSE)	**0.835**					
Information search task memory experience (MemoryExp)	0.288	**0.822**				
Stress for red interruptions (Stress.Red)	-0.201	0.041	**0.806**			
Stress for gray interruptions (Stress.Gray)	-0.113	-0.087	0.571	**0.793**		
Information search task memory self-efficacy (MemorySE)	0.531	0.321	-0.241	-0.227	**0.877**	
Computer experience (CE)	0.613	0.115	-0.258	-0.167	0.407	**0.841**
Note: Diagonal elements in bold are square roots of the average variance extracted						

Construct validity is further confirmed when the indicators load above 0.50 on their associated constructs and when the loadings within constructs are higher than those across constructs (Chin 1998). Table I.3 presents the indicator loadings for this study. Visual inspection of these loadings and cross-loadings further confirms that all constructs had good convergent and discriminant validity.

Table G3. Item Loadings and Cross Loadings

	Computer self-efficacy (CSE)	Information search task memory experience (MemoryExp)	Stress for red interruptions (Stress.Red)	Stress for gray interruptions (Stress.Gray)	Information search task memory self-efficacy (MemorySE)	Computer experience (CE)
CSE1	0.715	0.108	-0.052	0.121	-0.084	0.176
CSE2	0.841	0.064	0.044	0.028	-0.037	-0.019
CSE3	0.887	0.007	0.006	-0.063	-0.012	-0.124
CSE4	0.798	0.006	-0.109	0.011	0.109	-0.027
CSE5	0.767	-0.031	0.036	-0.085	0.032	0.119
CSE6	0.865	0.034	-0.102	0.035	-0.036	0.025
CSE7	0.906	0.001	-0.061	-0.049	-0.117	0.061
CSE8	0.927	-0.058	0.074	0.017	0.045	-0.136
CSE9	0.722	-0.024	0.105	-0.013	0.168	0.051
CSE10	0.885	-0.076	0.096	0.005	0.002	-0.004
MemoryExp1	-0.055	0.886	0.027	-0.010	0.026	0.038
MemoryExp2	0.012	0.979	-0.020	0.023	-0.064	-0.034
MemoryExp3	-0.003	0.952	0.024	-0.031	-0.019	-0.049
MemoryExp4	0.026	0.610	-0.026	0.008	0.221	0.108
MemoryExp5	0.046	0.600	0.009	-0.024	-0.049	-0.108
Stress1.Red	0.030	-0.021	0.971	-0.071	-0.025	-0.001
Stress2.Red	-0.053	-0.003	0.954	-0.029	0.002	0.025
Stress3.Red	0.028	-0.016	0.745	0.039	0.018	-0.039
Stress4.Red	0.092	0.086	0.708	0.090	-0.098	0.006
Stress5.Red	-0.028	-0.003	0.583	0.180	0.110	-0.034
Stress1.Gray	-0.103	-0.044	0.162	0.605	-0.018	0.104
Stress2.Gray	-0.060	0.026	0.118	0.625	0.026	0.011
Stress3.Gray	0.024	-0.011	-0.009	0.892	-0.037	0.026
Stress4.Gray	0.034	0.017	0.062	0.813	-0.024	0.006
Stress5.Gray	0.056	-0.031	-0.114	0.965	0.039	-0.112
MemorySE1	0.062	0.098	0.047	-0.012	0.545	0.133
MemorySE2	0.101	-0.064	-0.011	-0.019	0.928	-0.059
MemorySE3	-0.021	0.003	-0.051	0.025	0.978	-0.022
MemorySE4	-0.032	-0.008	0.024	-0.004	0.981	0.000
CE1	0.057	-0.017	-0.003	0.029	0.029	0.924
CE2	0.177	0.011	-0.024	0.002	0.030	0.682
CE3	0.082	-0.081	-0.005	-0.040	-0.047	**0.895**

Appendix H

H1 Post Hoc Mediation Analyses

H1.1 Post Hoc Test for the Mediating Role of Perceived Mental Workload

To assess the mediating role of perceived mental workload between interruption frequency and stress, we employed Baron and Kenny's (1986) causal steps method. Step 2 of this method was significant at the 0.05 level, and Step 3 was significant at the 0.001 level. Further, there was no direct effect of interruption frequency on stress when mental workload was controlled for ($p > 0.05$), indicating full mediation. Although frequency did not show a direct effect on stress (Step 1, b = 0.137, std. error = 0.181, $p > 0.05$) and, thus, lacks the precondition of a "total" relationship with stress when considered alone, concluding that a mediating relationship exists is still warranted. Recent research has relaxed this precondition and argued that mediation inferences are justified when the indirect effect carried by the paths between the independent variable and the mediator (a path) as well as between the mediator and the dependent variable (b path) is significant (i.e., Steps 2 and 3; Kenny et al., 1998; MacKinnon et al., 2002).

H1.2 Post Hoc Test for the Mediating Role of Stress

Concerning the mediating role of stress between mental workload and performance, Step 2 of Baron and Kenny's (1986) method was significant at the 0.001 level, and Step 3 was significant at the 0.01 level. Further, there was no direct effect of workload on performance when stress was controlled ($p > 0.05$), indicating full mediation. Although mental workload did not show a direct effect on task performance (Step 1, b = -0.025, Std. Error = 0.092, $p > 0.05$) and, thus, lacks the precondition of a "total" relationship with performance when considered alone, we can conclude that a mediating relationship exists since the indirect effect carried by the paths between mental workload and stress (a path) as well as between stress and performance (b path) was significant (Kenny, et al., 1998; MacKinnon et al., 2002)

H1.3 Post Hoc Test of Mediated Moderation for Age-related Impacts

Formal tests of mediated moderation were conducted using the generally agreed-upon procedure developed by Baron and Kenny (1986), who also initially coined the term *mediation moderation* (Mueller et al., 2005; Preacher et al., 2007).

For the mediating role of inhibitory effectiveness between age and the core model, in Step 1 none of the control variables were significantly related to mental workload. However, in Step 2, the main effect of interruption frequency on workload was significant ($p < 0.05$), while age was not a significant predictor. This result demonstrated the role of age as a full rather than only a quasimoderator when considered together with the finding from Step 3, in which the frequency × age interaction term was significantly related to workload ($p < 0.05$). In Step 4, inhibitory effectiveness did not have a main effect on workload. In Step 5, the frequency × inhibition interaction term had a significant effect on workload ($p < 0.05$). Further, the frequency × age interaction term became nonsignificant in the presence of the frequency × inhibition interaction term, indicating that the moderating effect of age was explained by the moderating impact of inhibitory effectiveness. For the mediating role of computer experience between age and the core model, a similar pattern was observed. In Step 4, computer experience did not have a main effect on workload. In Step 5, the frequency × computer experience interaction term had a significant effect on workload ($p < 0.05$). Furthermore, the frequency × age interaction term became nonsignificant in the presence of the frequency × computer experience interaction term, indicating that the moderating effect of age was explained by the moderating impact of computer experience.

Concerning the mediating role of computer self-efficacy (CSE) between age and the core model, in Step 1 none of the control variables were significantly related to stress. However, in Step 2, the main effect of mental workload on stress was significant ($p < 0.05$), while age was not a significant predictor. This result demonstrated the role of age as a full rather than merely a quasi-moderator when considered together with the finding from Step 3, in which the workload × age interaction term was significantly related to stress ($p < 0.05$). In Step 4, CSE did not have a main effect on stress. In Step 5, the workload × CSE interaction term had a significant effect on stress ($p < 0.05$). Also, the workload × age interaction term became non-significant in the presence of the workload × CSE interaction term, indicating that the moderating effect of age was explained by the moderating impact of CSE.

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