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The Role of Age in Technology-induced Workplace Stress

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THE ROLE OF AGE IN TECHNOLOGY-INDUCED WORKPLACE STRESS

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Management

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by
Stefan Tams
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Accepted by:
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Abstract

Recent research shows that such Information and Communication Technologies (ICTs) as instant messengers can cause workplace interruptions, which lead to stress for employees and substantial productivity losses for U.S. organizations. Since the introduction of ICTs, workplace interruptions have evolved in both frequency and nature from irregular phone calls to a continuous stream of e-mail notifications and other electronic interruptions, mediated through a large number of technological devices that constantly beep and buzz. This trend of an increasing frequency of workplace interruptions closely relates to another workplace trend: the graying of the workforce, implying that the U.S. workforce is aging at an increased rate. Since older people are particularly vulnerable to interruptions, the interdependencies inherent in these two workplace trends need to be better understood. Accordingly, this dissertation aims to understand *whether, how, and why technology-mediated (T-M) interruptions impact stress and task performance differently for older compared to younger adults.*

To examine these questions, this research applies two complementary theoretical frames that explain interruptions' influence on older and younger adults' cognition. First, the Person-Environment Fit perspective suggests that T-M interruptions may lessen the fit between the mental resources available for performing a task and those required, thereby inducing workplace stress and, in turn, reducing individual task performance. Second, the Inhibitory Deficit Theory of Cognitive Aging holds that older peoples' ability to actively disregard distracting stimuli is impaired. Thus, more T-M interruptions may “steal” resources from the processing of task-related content in older adults.

In combining these theories with user characteristics and technology features, this research develops an integrative model of ICTs, aging, stress, and task performance. We propose that older people are more distracted by T-M interruptions than younger, thereby experiencing greater mental workload and, in turn, more stress and lower performance. We test the model through a laboratory experiment that integrates the manipulation of ICT features with objective measures of stress and task performance, unlike the subjective measures commonly used. Experimental manipulations include the frequency with which interruptions appear as well as such interruption design characteristics as color codes. Outcome measures include actual performance in terms of the number of task elements solved, as well as the change in stress hormones found in saliva, a state-of-the art physiological measure of stress.

In developing and testing the model, we help to clarify the role of age in technostress. This research also sheds more light on the mental processes that connect ICTs to stress and performance, and it has begun to open the black box of the ICT features linked to these outcomes. For managers, we provide guidance on assisting older employees in realizing their full potential for contributing to firm success. This research further advises systems designers on such issues as user involvement.

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Table of Contents

List of Tables

List of Figures

Chapter One: Introduction

Laura Oldfellow, who just turned 67, has to use information and communication technologies (ICTs) in support of her work as a sales manager. She has a positive attitude toward the technology and believes it may be useful to her job, but faces great trouble in using it effectively – in contrast to Frank, a sales agent 27 years of age who grew up with ICTs. Laura is especially bothered by frequent interruptions, such as unexpected emails and pop-ups, which characterize today's busy computing environments. She found them particularly disruptive to do mental work. While Laura could slightly improve her interaction with the system by using the few accessibility options for older people it provides, she resents to clicking on a handicap icon to access these options – after all, she considers herself a senior citizen, not a handicapped one. As a result of these problems, Laura is frustrated and her well-being and workplace performance are threatened. But she is not alone: many older people share her experiences and think the computer age has passed by them: ***"It's not for me, I am too old"***.

1.1 INTRODUCTION

This vignette illustrates the interdependencies of two workplace trends: the "graying of the workforce" and the ubiquity of technology in U.S. organizations (Ginn & Arber, 1996; Panek, 1997, p. 363). The median age of 32 in 1990 is expected to increase to 42 by 2030 and the population historically associated with retirement (i.e., people over 65) will constitute the fastest growing part of the U.S. workforce, reaching almost a quarter of the entire U.S. population by 2030 (Howell, 1997; Panek, 1997). Legislation that prohibits age discrimination, mandatory retirement (enacted by Congress in 1896), as well as economic factors that motivate employees to stay in the workforce longer (Panek, 1997) leaves U.S. organizations with a workforce whose demographic attributes are changing dramatically (U.S. Bureau of Labor Statistics, 2008; Morris et al., 2005).

Yet, although we know that older and younger people interact differently with technology (Venkatesh et al., 2003), ICTs tend to be designed with little systematic regard for the older user (Fisk et al., 2009). While such older individuals as Laura often maintain positive attitudes about ICTs and believe that the benefits of technology use outweigh its costs, many older adults experience more difficulty than younger people do in using these technologies (Fisk et al., 2009). Older, when compared to younger, adults feel less confidence in their ability to successfully use ICTs and experience more anxiety when interacting with these systems (Czaja et al 2006; Lam & Lee, 2006), as illustrated by the common thought: “It’s not for me, I am too old” (Brown, 2002, p. 28B). And with ICTs growing more ubiquitous, from PC systems to Wi-Fi phones, and as they enable work environments that are increasingly characterized by such frequent interruptions as pop-ups, instant messages, and e-mails, there is evidence that older people are feeling increasingly overwhelmed and frustrated (Greengard, 2009; Hasher & Zacks, 1988; Tarafdar et al., 2007).

Indeed, since older people have entered the workforce in the U.S., technology has dramatically increased the diversity of ways and the ease with which employees can be interrupted or distracted in their work (Spira, 2007). Workplace interruptions have evolved in both frequency and nature from irregular phone calls, post-it notes, and walks into colleagues’ offices, to a continuous stream of e-mail notifications, instant messages, meeting reminders, task reminders, and other interruptions, all mediated via a multitude of technological devices that constantly beep and buzz (Basoglu & Fuller, 2007; Spira, 2007). Today, personal digital assistants, e-mails, e-mail reminders, chat tools, computer-based phone systems, computer-based video-conferencing, news feeds, stock quotes, and automated task lists are all continuously calling for peoples’ attention. On top of this, the internet invites employees to interrupt themselves with such entertaining distractions as cartoons and online games (Basoglu & Fuller, 2007; Spira, 2007).

By shifting to ICT-enabled work-environments with all their benefits, organizations have also opened a Pandora’s Box, filled with countless interruptions. No longer can people simply close their office doors or not answer the phone; no longer can they create fortresses of solitude to shield themselves from interruptions (Spira, 2007). Instead, the sheer quantity of interruptions has increased dramatically. In fact, interruptions now consume almost a third of employees’ work days (Spira, 2007), leaving them working (or, attempting to work) in an interruption era. Not surprisingly, in part because they “grew up” in a world with fewer interruptions, older, compared to younger, adults tend to be particularly overwhelmed and frustrated within ICT-enabled work-environments. More specifically, older people report more stress when using ICTs for mentally challenging tasks and often perform more poorly on computer-based tasks (Czaja & Sharit, 1998; Sharit et al., 1998).

This dissertation focuses on improving our understanding of age-based effects on stress and task performance in an ICT-enabled work environment, characterized by such frequent technology-mediated (T-M) interruptions as unexpected instant messages, pop-ups, or emails. Since older compared to younger adults are more vulnerable to interruptions (Hasher & Zacks, 1988) and more likely to exhibit performance deficits in the workplace under high cognitive demands (Murphy, 1989) created by interruptions, the strong stress responses and associated productivity losses linked to T-M interruptions

(Riemer & Frößler, 2007; Spira, 2007; Stephens, 2007) are likely to be even more substantial for older compared to younger workers.

In pursuing understanding of age's interplay with stress and ICT, we extend two literature streams. First and foremost, we add to the understanding of age-based differences in human interactions with technology. Few studies in IS focus on older individuals (e.g., Lam & Lee, 2006; Morris et al., 2005), although age is considered a key demographic variable for IS research (Venkatesh et al., 2003). Second, we extend understanding of the processes that cause T-M interruptions to create stress in users. Research in the domain of technostress (i.e., the stress experienced by individuals in organizations as a result of their ICT use, Ragu-Nathan et al., 2008) tends to presume that ICTs create stress in a universal fashion. For example, in their seminal book on technostress, Weil and Rosen (1997) largely ignore issues related to individual differences, thereby essentially presuming that ICTs affect all people equally. Yet, stress arises from an individual's reaction to a stimulus that is shaped by cognitive processes associated with stressor recognition and assessment (Lazarus, 1993; 1999), not from the specific stimulus per se.

Hence, our broad objective is to understand *whether, how, and why T-M interruptions impact stress and task performance differently for older compared to younger adults*. In the following sections within this chapter, we provide an introduction to this dissertation. More specifically, in the next section, we state our research questions and briefly situate them in the extant literature. Following this, we briefly develop a core model of technostress by discussing person-environment fit as an essential contributing theoretical perspective. We then build on this core by elucidating the touch points of age using an important theoretical approach to cognitive aging. A brief illustration of the research design follows, before we provide an overview of this study's implications for research and practice. We conclude our introduction to this dissertation with an outline of its structure.

1.2 STUDY OBJECTIVES

We examine the following research questions:

- *Does the level of stress generated by technology-mediated interruptions vary with adult age, and if so, how and why does this occur?* Precious little work has been conducted on the role of age in the formation of technostress and results have been inconclusive. For instance, Ragu-Nathan et al. (2008) found that technostress decreases as age increases, while Tu et al. (2005) concluded that the opposite is true. These conflicting findings are largely a function of our immaturity in this topic (Huber, 1983). For example, age has been superficially "thrown in" as a variable with little understanding of the theoretical nature of the concept. No theory of aging has been applied to predict age effects in the technostress context and understand the findings. Not surprisingly, recent research has called for an examination of the role of age in technostress (Tarafdar et al., 2007).

- *Do performance decrements generated by technology-mediated interruptions vary with adult age, and if so, how and why does this occur?* While little is known about the relationship between age and performance in the context of technology-based tasks (Sterns et al., 1994), the relationship has been studied for over a century in Psychology (Panek, 1997). Similarly, the link between stress and performance has rarely been examined in the technostress literature, although organizational stress research argues that employee well-being is of little business value if it does not translate into performance benefits (Hart & Cooper, 2001). If T-M interruptions and associated stress constitute an important inhibitor of organizational productivity (Spira, 2007) in an aging U.S. society and workforce (Ginn & Arber, 1996), it is critical to understand how they manifest themselves.

1.3 CORE RESEARCH MODEL

To develop a parsimonious yet powerful core research model as a basis for answering our research questions, it is important to first identify an appropriate theoretical frame. Such a frame would allow us to ground our model in prior research, enabling a cumulative research tradition and informing the relationships of interest to us. Our literature review finds that stress arises from the interaction between a person and the environment rather than from a stimulus per se, suggesting that the Person-Environment fit perspective (P-E fit; Pervin, 1968) constitutes a suitable theory to understanding individual differences in a model of technostress (Caplan, 1987; Edwards, 1996; Lazarus, 1999). The P-E fit perspective holds that all facets of behavior and performance result from the perceived transaction or interaction between an individual and such environments as the workplace. It is concerned with subjective evaluations of fit between a person and her workplace in terms of abilities and skills. An improved perceived fit is associated with less stress and higher performance, while a perceived misfit results in stress for the employee and poor performance (see Figure 1.1). The extent of fit or misfit is determined by a “relative balance of forces” between such perceived environmental demands as workload and an individual’s perceived resource availability for responding to them (Lazarus, 1999, p. 58). This relative balance of forces is analogous to a seesaw, with perceived environmental load (i.e., an external force or stressor, such as workload) on one side of the seesaw and perceived resource availability on the other side. As environmental load exceeds the available resources, implying a perceived mismatch between resource supply and demand as in the case of excessive workload, stress results. The resulting stress mediates the effects of stressors on task performance (Beehr, 1995; Chang et al., 2009).

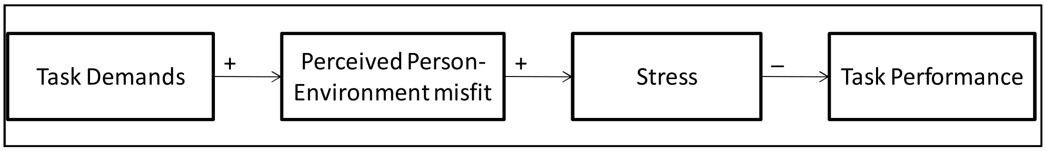

Figure 1.1 The Person-Environment Fit Perspective (adapted from Warburton, 1979)

The extant literature also indicates that T-M interruptions affect stress indirectly by creating P-E misfit (Ayyagari et al., forthcoming; Warburton, 1979). More specifically, it is the frequency of incoming interruptions that directly increases such misfit (Hasher & Zacks, 1988; Warburton, 1979). Further, the extant literature suggests that person-environment misfit in the form of high mental workload is the stressor that ultimately causes stress (Wickens et al., 2004). Mental workload perceptions reflect the perceived relative balance between the mental resources required for task performance (i.e., a form of perceived environmental demand) and those available (Hart & Staveland, 1988; Wickens et al., 2004). As such, it increases in correspondence with the cognitive demands in the environment (Strayer & Drews, 2007; Yeh & Wickens, 1988). Table 1.1 summarizes the key points from the contributing literatures that inform the development of our core model.

Key Takeaway	Elaboration	References
Stress formation is a *transactional process*.	Contemporary stress research considers stress formation a transactional process, meaning that stress arises not from a stimulus per se, but from the interaction between a person and the environment.	(Cooper et al., 2001; Hancock & Szalma, 2008; Lazarus, 1999; Ragu-Nathan et al., 2008; Tarafdar et al., 2007)
Since stress arises from the transaction between a person and a stressor, it can be studied through the *person-environment fit perspective.*	The person-environment fit perspective provides a framework for understanding how stress emerges from the interaction between a person and a stressor. As such, it is well-suited to address such individual differences as age in a model of stress. Further, this model incorporates the concepts of coping (e.g., through self-efficacy) and task performance.	(Bandura, 1982; Caplan, 1987; Edwards, 1996; Folkman & Lazarus, 1984; Lazarus, 1966, 1999; Ozer & Bandura, 1990; Pervin, 1968)
The *frequency of technology-mediated interruptions* impacts person-environment fit.	Technology-mediated interruptions indirectly affect stress through their impact on person-environment fit.	(Pervin, 1968; Warburton, 1979)
	The frequency of incoming distractions or interruptions reduces person-environment fit.	(Hasher & Zacks, 1988; Lazarus, 1999; Folkman & Lazarus, 1984; Zacks & Hasher, 1997; Warburton, 1979)
Perceived *mental workload* is the stressor that ultimately creates stress.	Perceived mental workload (i.e., the perceived ratio of the mental resources required to perform the current task to the resources available) is a stressor of particular importance in the form of person-environment misfit.	(Endsley, 1995; Hart & Staveland, 1988; Wickens et al., 2004)

Table 1.1 Key Aspects from the Contributing Literature that Inform the Core Model

Figure 1.2 presents the core model studied in this research. We draw upon the P-E fit perspective to theorize that by generating mental workload, the frequency of T-M interruptions induces stress[1], which subsequently diminishes task performance.

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[1] Prior research has labeled individual stress in diverse ways. For example, some (e.g., Galluch, 2009) referred to stress perceptions as stress and to physiological manifestations of these stress perceptions as strain. Others (e.g., Chang et al., 2009; Lang et al., 2007) referred to stress perceptions as psychological strain and to physiological experiences of stress as physiological or physical strain. Given this inconsistency in the terminology used in the extant literature, we rely on a simple label of experiences of stress. Specifically, whether experiences of stress are psychological or physiological in nature, we label them individual stress. Although this label is simple, it is useful for labeling stress in this particular study since we regard the nature of stress experiences (whether psychological or physiological) a measurement rather than a conceptual issue.

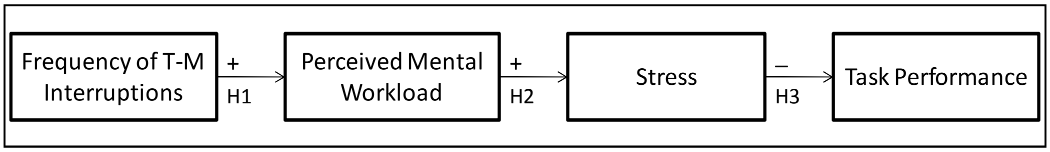

Figure 1.2 Core Research Model

1.4 AGE-RELATED MANIFESTATIONS

Since the P-E fit perspective is a relational approach that considers the person, it is well-suited for integrating individual differences into a model of stress (Lazarus, 1999). However, the perspective falls short in explaining how and why stress responses may vary across age groups. Using Selective Attention Theory (Houghton & Tipper, 1994), Social Cognitive Theory (Bandura, 1982), and the literature on Cognitive Aging (e.g., Park, 2000), we argue for three points related to the user and one related to the technology at which age impacts our core model.

Table 1.2 summarizes the key aspects from the contributing literature that inform these age manifestations. We refer to these manifestations as the 4 C's: Concentration, Cost, Confidence, and Capture. "Concentration" means that older compared to younger people face more trouble concentrating on the current task when T-M interruptions appear, thereby potentially experiencing higher levels of P-E misfit in the form of mental workload. The Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988), which is an important theoretical approach to aging (McDowd & Shaw, 2000; Smith, 1996), tells us why older people may be differentially bothered in this way by T-M interruptions. This view postulates an attentional inhibition mechanism that enables people to control attention and sustain the focus of attention on a particular active task despite the presence of distracting stimuli. The theory holds that attentional inhibition is impaired in older adults, thereby enabling more distractions to gain access to mental resources. This means that older compared to younger adults experience greater interference of distractions with current task processing, implying that fewer cognitive resources are available for processing task-related information (see Figure 1.3).

Key Takeaway	Elaboration	References
Selective attention is an individual's ability to selectively process some information sources and ignore others.	Since people cannot process all the stimuli that continuously bombard their senses, selective attention is necessary to ensure that the most relevant information is processed and less relevant information is excluded from receiving processing resources.	(Rogers & Fisk, 2001; Strayer & Drews, 2007; Houghton & Tipper, 1994)
Attentional inhibition increases selective attention efficiency.	Attentional inhibition enables people to deliberately suppress distracting information, thereby effectively reducing the quantity of distractions or interruptions that gain access to mental resources.	(Houghton & Tipper, 1994; Hasher & Zacks, 1988; Zacks & Hasher, 1997; Darowski et al., 2008)
Attentional amplification of distractions reduces selective attention efficiency.	Individuals are more likely to attend to stimuli that are amplified. Hence, distracting stimuli that are amplified through such mechanisms as flashing or stimuli that present a threat are more likely to gain access to mental resources.	(Strayer & Drews, 2007; Tipper & Houghton, 1994; Wickens et al., 2004)
Experience reduces the attentional requirements of a task.	Experience gradually replaces resource-intense effortful information processing for performaning a task by more efficient automatic processing. In so doing, experience reduces the cognitive burden associated with performing a task and frees mental resources.	(Lee et al., 2007; Liu et al., 2004; Rogers & Fisk, 2001; Sweller, 1988, 1994)
Cognitive aging refers to age-related changes in mental resources.	As individuals grow older, the availability of mental resources used to perform mental tasks becomes subject to change. Generally, older adults have fewer resources available.	(Park, 2000)
Older compared to younger peoples' *inhibitory mechanism is impaired,* resulting in lower task performance.	The Inhibitory Deficit Theory of Selective Attention suggests that - compared to younger individuals - older peoples' inhibitory mechanism is less effective, thereby enabling more distracting stimuli to gain access to mental resources and interfere with current task processing. As a result, a single train of thought cannot be maintained, and progress on the current task becomes slowed and error-prone.	(Darowski et al., 2008; Hasher & Zacks, 1999; Hasher et al., 1991; Zacks & Hasher, 1997)
Older compared to younger peoples' *amplification mechanism is more effective,* resulting in lower task performance.	Compared to younger individuals, older people are more likely to attend to amplified stimuli, thereby enabling more distracting information to gain access to mental resources and interfere with current task processing. As a result, a single line of thought cannot be maintained, and progress on the current taks becomes slowed and error-prone.	(Fisk et al., 2009; Lorenzo-Lopez et al., 2008; Pratt & Bellomo, 1999; Whiting et al., 2007)
Older compared to younger people have *lower levels of user experience* .	As a result of their lower user experience, older compared to youngeradults may gain less of a reduction in the attentional requirements of the current task. Older adults may need more cognitive resources to operate the computer, e.g. moving the mouse across the screen.	(Panek 1997; Sharit & Czaja, 1999)
Older compared to younger people have *lower levels of computer self-efficacy* .	As a result of their lower computer self-efficacy, older people may feel more threatened in stressful situations that involve a computer.	(Czaja et al., 2006; Marakas et al., 1998)

Table 1.2 Key Aspects from the Contributing Literature that Inform Age Manifestations in the Core Model

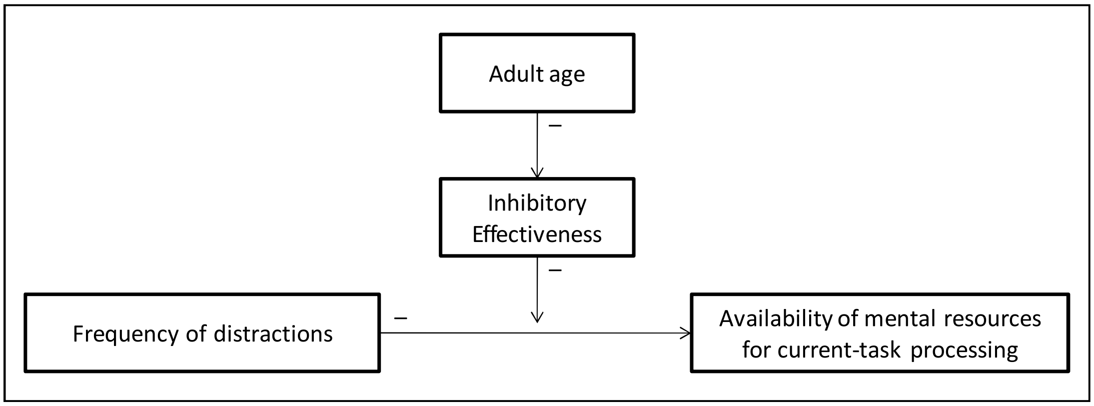

Figure 1.3 The Inhibitory Deficit Theory of Cognitive Aging

"Cost" means that older compared to younger adults incur higher resource-related costs when attending to T-M interruptions, thereby potentially experiencing higher levels of mental workload. Research generally speculates that experience can compensate for age-related declines in cognitive abilities (Sharit & Czaja, 1999) and performance (Panek 1997). In fact, experience is the most considered factor in understanding the conditions under which associations between age and task performance manifest themselves (Panek 1997). Experience reduces the cognitive burden associated with the performance of a task and frees mental resources (Sweller, 1988; 1994). Since older compared to younger adults tend to have less experience with contemporary ICTs due to different educational experiences regarding technology and lower perceptions of ease of use, two major antecedents to computer experience (Czaja et al., 2006; Hawthorn, 2007), they may need relatively more cognitive resources for adequately performing computer-based tasks. Hence, their effective costs of attending to distractions are higher (i.e., T-M interruptions "steal" a greater amount of resources from the processing of desired content). It deserves mentioning that – perhaps because computer experience generally plays a critical role in individuals' interactions with ICT (Taylor & Todd, 1995; Venkatesh et al., 2003) – recent research (Tarafdar et al., 2007) called for an analysis of the effect of experience on technostress.

The term "Confidence" reflects the essence of self-efficacy (Bandura, 1982; Kahn & Byosiere, 1992). Computer Self-Efficacy (CSE) refers to individuals' perceptions of their ability to use a computer in support of work tasks (Compeau & Higgins, 1995) and hence reflects peoples' judgments of how well they can use a computer to deal with such prospective situations as stressful events (Bandura, 1982). Age is an important antecedent to CSE because older people tend to have lower self-efficacy with respect to computer use (Czaja et al., 2006; Marakas et al., 1998). As a result of their lower efficacy, older individuals compared to younger ones may be less able to deal with stressful situations (Czaja et al., 2006).[2] Dealing with stressful events (i.e., coping) is an integral part of the stress process that should complement any study of stress (Lazarus, 1999). Specifically, since perceptions of inadequacy promote threats, people who do not believe in their ability to do what is required tend to be more threatened in stressful situations and in turn more stressed (Folkman et al., 1979; Lazarus, 1999).

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[2] Since research on aging in the context of information systems is still in its infancy (see chapter two), we are exploring the impact of computer experience and computer self-efficacy as key constructs through which age may impact individuals' technostress. More specifically, little research has explored potential reasons for differential implications of computer experience and computer self-efficacy for younger and older adults, let alone in the context of technostress. Additionally, studies examining the role of age in the technostress context have done so in an atheoretical fashion (e.g., Ragu-Nathan et al., 2008; Wang et al., 2008). We attempt to build preliminary theoretical arguments for these touch points in our subsequent chapters.

“Capture” means that the salience of T-M interruptions can be enhanced through such means as flashing or an alerting color so that these interruptions more effectively capture users’ visual attention. Recent research (e.g., Fisk et al., 2009; Lorenzo-Lopez et al., 2008; Pratt & Bellomo, 1999) suggests that older compared to younger adults may be more susceptible to stimulus-driven capture of visual attention, which refers to the attentional priority salient events receive over non-salient ones in such visual fields as ICT displays. This research theorizes that because older compared to younger people often suffer from slowed and less precise visual search, any salient feature in a display should have a particularly strong impact on them. In effect, older adults are more likely to be affected by such salient stimuli as flashing or stimuli that present a threat.

Figure 1.4 presents our expanded model, with construct definitions provided in Table 1.3. Using the Inhibitory Deficit View, we propose that individuals with lower inhibitory effectiveness will incur stronger effects of interruptions on P-E misfit in the form of mental workload. Second, because experience generally reduces the cognitive burden associated with the performance of a task and frees mental resources (Sweller, 1988; 1994), computer experience may reduce potential negative impacts of T-M interruptions on individuals’ perceptions of mental workload. Finally, since self-efficacy generally helps people cope with stressful events (Bandura, 1982; Czaja et al., 2006), individuals with lower CSE will incur stronger effects of mental workload perceptions on experiences of stress.

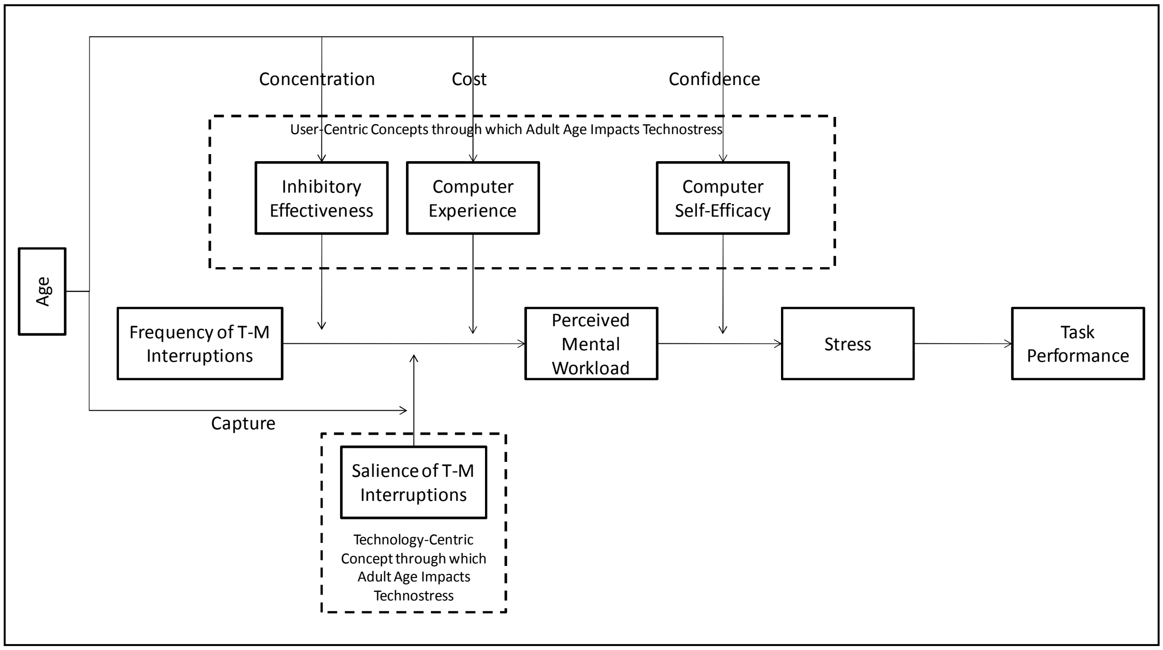


Figure 1.4 Research Model augmented with age manifestations

Construct	Defintion
Frequency of T-M interruptions	Number of technology-mediated (T-M) distractions in a given time interval that shift individuals' attention away from a current task and require conscious effort to return to the original task (Damrad-Frye & Laird, 1989; Galluch; 2009).
Perceived mental workload	Perceived ratio of mental resources required to accomplish a task to mental resources available. Working memory capacity is a major such resource. Such distractions as T-M interruptions reduce the mental resources available for the current task, thereby increasing perceptions of mental workload (Hart & Staveland, 1988; Wickens et al., 2004).
Stress	Extent to which an individual responds psychologically or physiologically to a perceived misfit between resource availability for current task performance and environmental resource demand (Caplan et al., 1975; Lazarus, 1966; 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 distracting information, thereby preventing distractors from gaining access to mental resources. An inhibitory deficit implies higher susceptibility or vulnerability to distraction (i.e., lower selective attention performance) (Hasher & Zacks, 1988; Zacks & Hasher, 1997).
Computer experience	Extent to which an individual has been using computers over his or her lifetime (Harrison & Rainer, 1992; Taylor & Todd, 1995).
Computer self-efficacy	Extent to which an individual beliefs in 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 are salient in terms of color, dynamism, and aural features (Houghton & Tipper, 1994; Strayer & Drews, 2007; Wickens et al., 2004).
Age	Chronologically younger compared to older individuals (Hasher et al., 1991; Hasher & Zacks, 1988; Zacks & Hasher, 1997).

Table 1.3 Construct Definitions

Further, we argue that older compared to younger users (1) have lower levels of inhibitory effectiveness and therefore more trouble concentrating on the current task when T-M interruptions appear, (2) have lower levels of computer experience and hence incur higher resource-related costs from attending to these interruptions, (3) have lower confidence and are hence less likely to deal effectively with high levels of mental workload arising from these interruptions, and (4) tend to be more susceptible to stimulus-driven capture of visual attention. Since salient display features receive processing priority over non-salient ones (Fisk et al., 2009), we expect interruptions whose salience is enhanced through such design characteristics as flashing or an alerting color to be more likely to gain access to mental resources and interfere with current-task processing, particularly for older people. As a result, older compared to younger individuals' perception of mental workload, well-being, and associated task performance are more likely to suffer when T-M interruptions appear.

1.5 RESEARCH DESIGN

This dissertation employs a laboratory experiment to test the hypothesized relationships. Figure 1.5 provides an overview of the general approach this research takes to design the experiment. First, appropriate incentives need to be identified so that the participants can be motivated to perform at a high level. Next, an experimental task has to be identified to which such major aspects of our research model as working memory and sustained attention requirements are relevant. Third, with the purpose of examining interactions between interruption design, frequency, and age, an appropriate design type needs to be identified that allows us to manipulate such interruption attributes as the color and the frequency of incoming interruptions. Further, it is important to determine a sample size that yields sufficient statistical power. In addition, the experimental procedures and manipulations have to be established, along with the measures for non-manipulated constructs and the plans for the pre- and pilot-tests.

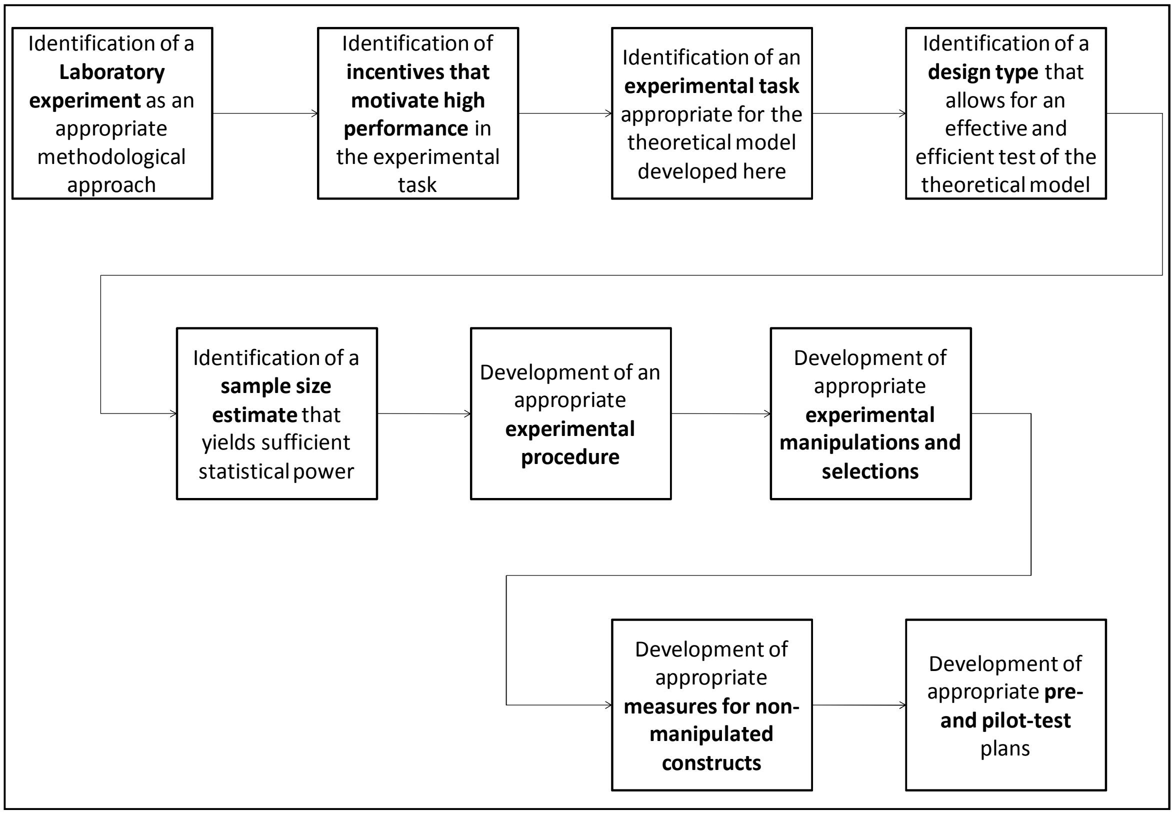


Figure 1.5 Overview of the Methodological Development

We use a lottery with valuable prices to motivate our participants to perform well in the experimental task and ensure that the task has meaning to them. Concerning the experimental task, we employ the online browser memory game Concentration, which has previously been used in research on age-related differences in cognitive functioning (e.g., Schumann-Hengsteler, 1996). In the Concentration task, subjects have to find matching pairs of symbols by flipping computer-generated cards. In the process, they have to memorize the symbols they have seen and where the symbols are hidden. To ensure that T-M interruption can quickly and substantially reduce the working memory capacity available for the Concentration task and easily interfere with the information processing necessary for the task, we use arithmetic and design cards specifically for this task. One card contains an integer number, and another card contains a matching multiplication that yields this integer number. For example, a matching pair of cards could consist of one card with the symbol “15” and another card with the symbol “5 * 3.” T-M interruptions appear on the screen within specific time intervals.

This dissertation uses a within-subjects design with two levels per factor, allowing us to clearly delineate any moderating influence of these factors without unreasonably inflating the experimental design. Since neither the relationship between adult age and inhibitory effectiveness nor the one between feature salience and attentional capture is considered to be curvilinear (Darowski et al., 2008; Yantis & Egeth, 1999), employing middle groups for these factors would not enhance our understanding of their interaction with the frequency of incoming interruptions. Using this design requires a sample size of 90 participants to yield adequate statistical power.

Consistent with the literature on the Inhibitory Deficit View (e.g., Hasher et al., 1991; Zacks & Hasher, 1997), this dissertation uses two age groups: younger and older people. Also consistent with the Inhibitory Deficit Theory, we define as younger those people between 18 and 27 years of age and as older those between 60 and 85. As regards the salience of T-M interruptions, color as a design features associated with stimulus-driven attentional capture is manipulated by employing a lower and a higher level. Finally, the frequency with which T-M interruptions appear is manipulated by using two frequencies that allow us to examine any effect of interruption frequency on person-environment fit due to high cognitive demands, which constitute our focal interest.

Consistent with prior research in the area of age-related differences in distractibility (e.g., Carlson et al., 1995; Connelly et al., 1991), this research uses students as representatives of younger individuals and older workers as well as retirees from the community as representatives of older adults. We recruit students from undergraduate classes at a large southeastern university by means of email, discussion boards, and announcements. Older adults are recruited from the local community through newspaper advertisements and university contacts. In the recruitment process, we provide information regarding participation purpose, associated risks, and incentives.

This research further employs both objective and subjective outcome measures. Measures include actual task performance, change in actual stress hormones found in saliva supplemented with individual perceptions of stress, the NASA Task Load Index (TLX; Hart & Staveland, 1988), and the STROOP color-word task (Stroop, 1935). We use these four tests to evaluate individual performance, strain, fit between mental resources available and required for task performance, and capacity to actively disregard distracting stimuli, respectively. Collectively, these tests advance understanding of how and why T-M interruptions negatively affect employee well-being and performance, and how these effects depend on adult age.

We measure task performance as the number of matching pairs uncovered in the Concentration task. To evaluate change in stress hormones, we obtain salivary measures of alpha-amylase using salivettes. The NASA TLX is a comprehensive and multidimensional subjective measure of mental workload. It is a well-validated instrument that derives an overall workload score from a weighted average of ratings on six relatively independent sub-dimensions, which relate to the interaction between a person and certain environmental demands. The STROOP task requires subjects to ignore attentionally compelling but unwanted signals and to suppress responses to these signals while working on another task. It presents color names printed in non-consistent ink colors and requires subjects to actively inhibit the printed names of colors, while selectively attending to the ink color in which the words are printed.

The experimental room is organized to control for extraneous distractions. All work tables face walls and all jalousies are closed. We further control for relevant alternative explanations pertaining to mental workload perceptions, stress, and task performance.

1.6 RESEARCH CONTRIBUTIONS

This research addresses the need for studies that clarify the relationship from adult age to technostress. Similarly, this research extends the nascent literature on T-M interruptions, workplace stress, and performance. By proposing a theoretical model of T-M interruptions and adult age and testing this model through a laboratory experiment, this dissertation advances research and contributes to practice.

1.6.1 CONTRIBUTIONS TO THEORY

We contribute in a number of ways to theory on technostress. Perhaps most importantly, we begin to resolve the conflicting findings regarding the role of adult age in technostress. While a few studies have examined the role of age in this context (e.g., Ragu-Nathan et al., 2008; Tu et al., 2005), they have added this variable superficially into their models with little understanding of its theoretical nature. For example, Ragu-Nathan et al. (2008) simply suggested that–due to their greater maturity–older people can perhaps deal better with stressors than younger adults. Their age-related implications were limited to the idea that the possibly longer organizational tenure of older employees may result in more firm-specific experience and an improved understanding of how to assimilate the effects of ICTs. No such research has, to the best of our knowledge, employed a theory of aging to inform their models or interpret their results. By bringing an important theory of aging (McDowd & Shaw, 2000; Smith, 1996) to the attention of management scholarship in addition to developing and testing a model of the role of age in technostress, *we not only clarify the role of age in the context of technostress but also provide future studies with the opportunity to conduct theory-driven research on age*.

Two important additional contributions concerned with the formation of technostress feed into this clarification of the role of age. First, this dissertation extends understanding of the mental processes involved in the formation of technostress. Much prior research (e.g., Ragu-Nathan et al., 2008; Tarafdar, 2007; Tu et al., 2005) has proposed direct links between ICT-use and resulting stress without close examination of how this stress results. Such research has pointed to feelings of helplessness and frustration as linkages without arguing why these feeling result from ICTs. By positing on the basis of selective attention theory that T-M interruptions lead to person-environment misfit, *this dissertation sheds more light on the mental processes that connect ICTs to technostress*.

Similarly, this research opens the black box of the ICT characteristics that are associated with higher-than-usual stress levels. While the concept of technostress has been discussed for some time (Weil & Rosen, 1997), most studies employed fairly general ICT-related constructs. For example, Tarafdar et al. (2007) as well as Wang et al. (2008) did not incorporate any ICT-related drivers of technostress in their research models. Similarly, Ragu-Nathan et al. (2008) limited their discussion of technostress creators to generic technologies. By conceptualizing specific ICT-features or interruption design characteristics that capture attention involuntarily in a stimulus-driven way, *this research extends our conceptual understanding of the role of the IT-artifact in the technostress phenomenon*.

In the process of exploring the role of adult age, we also respond to recent calls for analyzing the effect of computer experience on technostress (Tarafdar et al., 2007). The present study indicates that experience with computers reduces the amount of mental resources required for computer-based tasks, freeing mental resources that can be used to improve interruption-handling. We conceptualize and test the concept as a moderator of the link between interruption frequency and person-environment misfit. In so doing, we indicate that computer experience is not a coping mechanism per se, meaning that it does not interact with ICTs to directly impact individual stress. Instead, computer experience interacts with ICTs to indirectly affect stress via the interaction's impact on person-environment fit perceptions.

This dissertation also adds to the growing body of literature on T-M interruptions by suggesting that the productivity losses associated with this phenomenon arise from reductions in task performance, which result from T-M interruptions via their indirect impact on individual stress. While prior research (e.g., Spira, 2007) has connected T-M interruptions to organizational outcomes, such studies have fallen short in explaining why such a link should exist. With the explicit inclusion of task performance in the research model, this study is among the first to begin examining how and why T-M interruptions impact organizational productivity.

1.6.2 CONTRIBUTIONS TO PRACTICE

From management and systems design standpoints, we show that age and T-M interruptions combine to result in stress, which subsequently reduces task performance. Managers recognize that ICTs can impose problems in the form of stress and reduced productivity (Mandel et al., 2005), yet they may not be familiar with meaningful strategies to counter these problems. By delineating the processes and conditions under which T-M interruptions create these problems, this dissertation contributes to managers' understanding of what particular buttons to push.

Computer training may be an outstanding strategy to counter the adverse effects of T-M interruptions on employee performance since it can simultaneously increase computer experience (Thompson et al., 1994; Tomporowski, 2003) and computer self-efficacy (Marakas et al., 1998; Yi & Davis, 2003), both of which can weaken the adverse effects of T-M interruptions. In serving this dual role, user training may provide an efficient avenue for managers to help employees handle stressful encounters with T-M interruptions. More specifically, by exposing individuals to a technology and thereby increasing their experience with it, computer training enables people to use ICTs with reduced mental effort. As a result, users will be better able to deal with T-M interruptions and will hence incur a weaker person-environment misfit from such interruptions. At the same time, training builds computer self-efficacy and thereby increases users' perceptions of their ability to use the computer in support of their works tasks. Hence, individuals will be less likely to feel threatened by any potentially arising misfit with their work environment on the basis of T-M interruptions. However, computer training programs may need to be *tailored to different age groups* since learning differences across age groups are relevant for computer training (Van Fleet & Antell, 2002). For instance, older people require approximately twice as much time as younger to complete computer training tasks and learn computer-related skills (Morris et al., 2005).

Similar to managers, systems designers learn what levers to pull to reduce potential negative impacts of their systems on users and subsequent organizational outcomes. Since there tends to be a large gap between younger designers and older users, involving older compared to younger adults in the design process could be even more important (Newell et al., 2006). This also implies that systems designers should regularly test their systems on populations reflective of the actual users (e.g., older people) rather than on convenience samples as commonly done (Jeng, 2005).

1.7 STRUCTURE OF THIS DISSERTATION

After having introduced the research questions in the preceding sections, we can now turn to situating these questions in the extant literature in chapter two. We begin with a review of stress research to identify a theoretical perspective that can inform the development of our research model. In the process, we also review the stress literature pertaining to T-M interruptions, aging, and coping as it relates to computer self-efficacy, and tie these concepts to the broader theoretical perspective. To further inform the relationship between T-M interruptions and technostress, we proceed with reviewing the literature on selective attention. The selective attention literature also informs our understanding of potential age-related manifestations and leads directly into the extant literature on cognitive aging, which deepens our understanding of how and why older people may be differentially bothered by T-M interruptions. We conclude our literature review with illustrating the relevant gaps this dissertation addresses, as well as with illustrating how this review informs the subsequent development of our research model in Chapter three.

To specify our research questions, we proceed by developing an integrative model of ICTs, aging, stress, and task performance. With the purpose of integrating all these concepts into a single unifying theme, we begin the development of our research model with a high-level discussion of the relationships involved. Following this high level discussion along with a visual representation of our research model, we develop concrete hypotheses that formalize and elaborate upon the proposed relationships. Specifically, we propose that older people are more distracted by T-M interruptions than younger individuals, thereby experiencing greater mental workload and, in turn, more stress and lower task performance.

We proceed in Chapter four by describing a laboratory experiment designed to test the model. We indicate that students are representative of younger adults, while community-dwelling older workers and retirees may well represent older adults. Further, we discuss the appropriateness of a computerized version of the memory game Concentration as the experimental task for this study, and we describe construct measures and manipulations as well as control variables. Moreover, we detail the experimental conditions and provide sample size estimates. We conclude our description of the research design with an overview of the pre- and pilot-tests as well as the data-analytic technique.

We discuss the results of our data analysis in Chapter five. We begin by describing the development of our measures and manipulations. In the process, we present the results of our pre- and pilot-tests. Next, we describe our final sample and evaluate the properties of our measures and manipulations, including reliability, convergent validity, and discriminant validity. We also discuss the measures taken to reduce any potential common method variance. Finally, we present the results of our hypothesis tests.

The key findings from our data analysis are further discussed in Chapter six, where we show how they contribute to information systems research. We also discuss the limitations of this study and offer implications for research and practice, showing how this research extends the literatures on technostress, selective attention, and age-related differences in human interactions with technology. We conclude this dissertation by providing directions for future research.

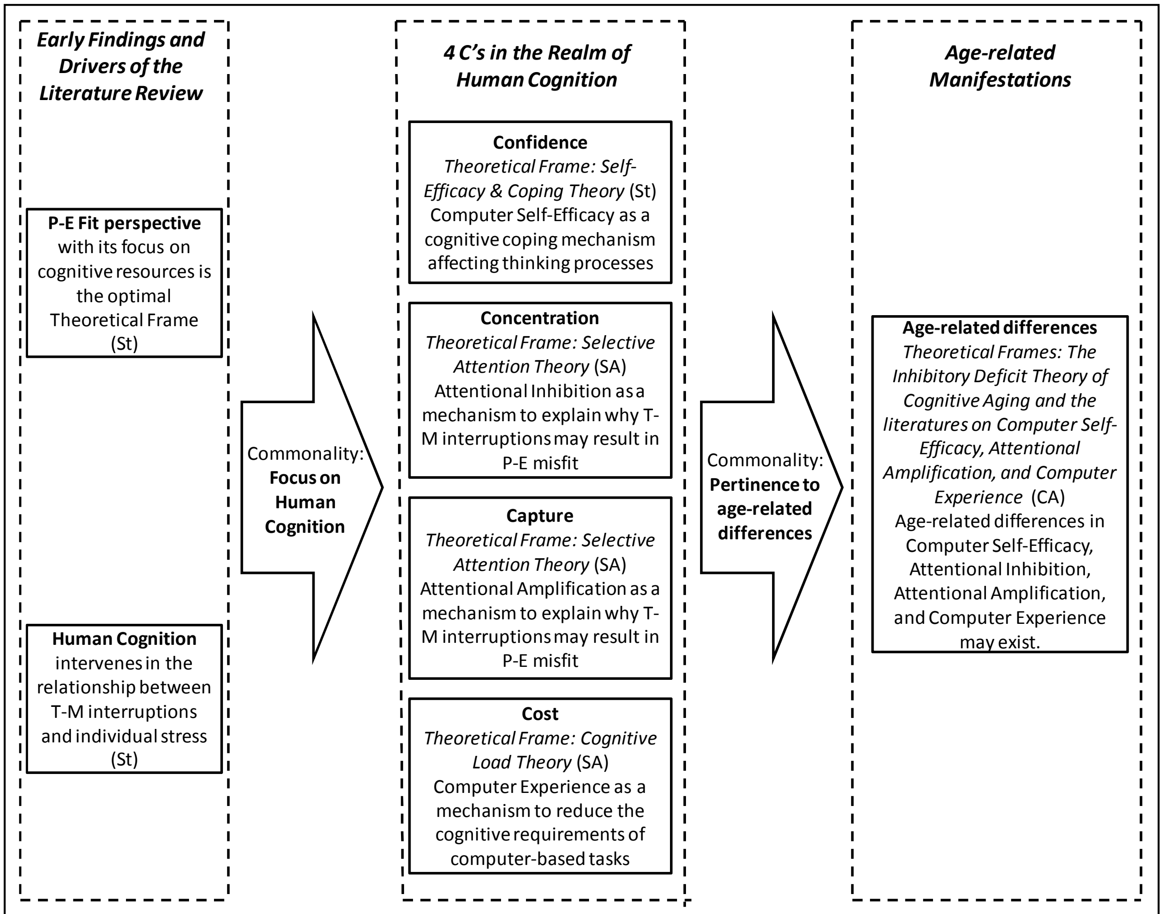
Chapter Two: Literature Review

2.1 INTRODUCTION

This chapter discusses the research streams and theories that subsequently serve to inform the development of our research model. We aim to identify the extant literature pertinent to the current study and reveal crucial gaps in the literature.

2.1.1 UNFOLDING OF THE LITERATURE REVIEW

To identify the extant literature relevant to this dissertation and uncover crucial gaps in the literature, we situate our research questions in three research streams: stress research, selective attention theory, and research on cognitive aging. We first review stress research to compare and contrast the major theoretical perspectives and select the most appropriate one for examining the role of age in a model of technostress. We find that the Person-Environment Fit perspective (P-E Fit), which assumes that stress arises from a perceived misfit between an individual's cognitive resources available for performing a task and those required (Lazarus, 1999), is the most appropriate theoretical framework for examining the role of age in a model of technostress. This is especially true since cognitive resources constitute a central avenue for explaining individual differences in stress responses (Warburton, 1979). Further, we discuss how T-M interruptions may impact the formation of stress and find that – consistent with the P-E Fit perspective's focus on cognitive resources – human cognition is generally believed to intervene in the relationship between T-M interruptions and such interruption outcomes as stress. Figure 2.1 illustrates how these findings drive the subsequent unfolding of our literature review.



Legend: Abbreviations in parentheses represent the three sections within which individual concepts are reviewed: St = Stress Research, SA = Literature on Selective Attention, and CA = Literature on Cognitive Aging.

Figure 2.1 Illustration of how the Literature Review Unfolds

Given the pertinence of human cognition to individual stress in general, and to T-M interruptions as well as individual differences in stress responses in particular, we focus our review of the literature on cognitive concepts that lend themselves to explaining how T-M interruptions may result in stress for individuals and how these experiences of technostress may depend on adult age. These cognitive concepts tie into the 4 C’s introduced earlier. Following a review of how age has been studied in the technostress domain, we review individual *Confidence* in the form of computer self-efficacy (CSE) as a concept inherently related to both the role of human cognition in stress responses (Bandura, 1989; Lazarus, 1999) and adult age (Marakas et al., 1998). According to Self-Efficacy Theory (Bandura, 1989; 1997) and Coping Theory (Lazarus, 1999), CSE, to which age is an important and known antecedent, affects thinking processes, thereby 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, which may differ between older and younger people, serve to regulate behaviors and feelings of threat in the presence (Bandura, 1989; 1997; Lazarus, 1999). We review CSE within the section on stress research since it constitutes a mechanism that helps people cope with stressful events.

Following the discussion of stress research, we review selective attention theory (Houghton & Tipper, 1994) to better understand why and under what conditions T-M interruptions may result in stress. We find that the attentional inhibition and amplification mechanisms, to which we refer as *Concentration* and *Capture*, respectively, can help explain when T-M interruptions may result in P-E misfit and why older people may be differentially affected. We also find on the basis of Cognitive Load Theory (Sweller, 1988, 1994) that computer experience, to which we refer as *Cost*, is pertinent to this dissertation since it reduces the cognitive requirements of computer-based tasks and, perhaps even more importantly, includes adult age as an important antecedent within its nomological net.

Finally, we review the literature on cognitive aging to gain a better understanding of age-related differences in the context of T-M interruptions. In the process, we review the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988; Zacks & Hasher, 1997), which is a major theory of cognitive aging consistent with the framework of selective attention, and examine whether and how adult age relates to CSE, attentional inhibition, attentional amplification, and computer experience. We find that all four concepts are pertinent to age-related differences in a model of technostress. This chapter concludes with a comprehensive summary to frame a model of T-M interruptions and adult age and to reveal crucial gaps in the literature.

2.1.2 A SIDE NOTE ON COMPUTER EXPERIENCE AND SELF-EFFICACY

This dissertation deviates in its treatment of computer experience and CSE to some extent from prior research. More specifically, it treats these concepts as largely distinct and reviews them in different sections, although they have sometimes been conceptually interrelated in the extant literature (e.g., Potosky, 2002). While this implies that these concepts' treatment in this dissertation may be inconsistent with a part of the extant literature, we see two principal reasons for why their separate discussion is more appropriate for this particular study than their combined discussion: (1) the mixed empirical support found in the literature for their relationship along with (2) the distinct roles these two concepts may 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 non-significant. 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 different extents to look back at prior task accomplishments 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 non-significant. 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, we find 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 – as we show later – CSE may weaken the effect of P-E 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 T-M interruptions on P-E misfit.

These distinct roles arise from the concepts' relations to distinct facets of human cognition. While CSE relates to thinking processes and 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).

In accordance with these distinct roles, CSE and computer experience will be reviewed in different sections. Since CSE constitutes a cognitive mechanism that helps people cope with stressful events, it will be reviewed within the section on stress research, allowing us to gain a deeper understanding of its role as a coping mechanism. Computer experience will be reviewed within the section on selective attention research, allowing us to gain a deeper understanding of its function as a mechanism to reduce the requirements of computer-based tasks for cognitive resources. Yet, despite their distinct roles in a model of stress, we find within our review of aging research that age-related differences are likely to exist for both constructs, although – as we show in subsequent chapters – different mechanisms are at play. While age differences in CSE exist on the basis of declining cognitive abilities, age differences in computer experience are due to differing educational experiences among older and younger adults along with systems design. Following our review of the literatures on stress, selective attention, and aging, we conclude this chapter with a comprehensive summary to frame a model of T-M interruptions and adult age.

2.2 STRESS RESEARCH

Individual stress has been widely studied in a diversity of disciplines. In the following sections, we find transactional stress perspectives in general, and the Person-Environment Fit perspective in particular, to be best-suited for examining the role of age in a model of technostress. We further discover that T-M interruptions affect stress indirectly through their impact on person-environment fit, and that the roles of age and computer self-efficacy are not sufficiently explored in the context of technostress.

2.2.1 OVERVIEW OF THEORETICAL PERSPECTIVES

Stress has been defined as a "particular relationship between the person and the environment that is appraised by the persona as taxing or exceeding his or her resources and endangering his or her well-being" (Lazarus & Folkman, 1984, p.19). Most contemporary stress research, including IS research, follows this perspective (Beaudry & Pinsonneault, 2005; Hancock and Szalma, 2008, p.5). According to this perspective, the correct unit of analysis is neither the individual nor the environment, but the transaction or interaction between the two. The view implies that, under the condition that the person lacks coping resources (i.e., the ability to deal with stressful events), stress arises when the resource demands of an external event or stimulus impose a threat to a person by exceeding the resources the person has available (Hancock and Szalma, 2008).

Consistent with this view, examining the role of such individual differences as adult age in a model of stress requires us to explain stress in terms of transactions between an environment and an individual rather than in terms of either one in isolation

(Lazarus, 1966, p. 5). In that vein, we compare and contrast prominent transactional stress perspectives in the following subsections with the objective of determining the most appropriate one for understanding the role of adult age in a model of technostress. Two conceptual frameworks are particularly prominent due to their conceptual significance and empirical success (Siegrist, 1996) and will be compared: the Demands and Control perspective and the Person-Environment Fit perspective.

2.2.1.1 Demands and Control Perspective on Stress

There is little doubt that the concept of control is important in our general understanding of stressor-stress relationships (Siegrist, 1996). Control is a central concept in the Demand-Control perspective (Karasek, 1979). The perspective was developed to clarify conflicting findings in the effects of work demands and decision-making freedom on stress. As such, the perspective focuses on the work environment and holds that stress varies with the work demands placed on an individual and the freedom allowed the individual in deciding how to meet these demands (Karasek, 1979). Such decision-making freedom relates to either the freedom to decide about aspects of the task or to decide about non-work elements, such as taking a break (Kasl, 1989).

According to the demand-control perspective, stressor-stress relationships are strongest when work demands are high and control in terms of decision authority is low (see Figure 2.2) (Karasek, 1979; Kasl, 1989; Siegrist, 1996). The perspective's implications focus on work process redesign to increase worker decision authority. For example, workers could be given the freedom to decide about whether and when to take a break or to make a personal telephone call.

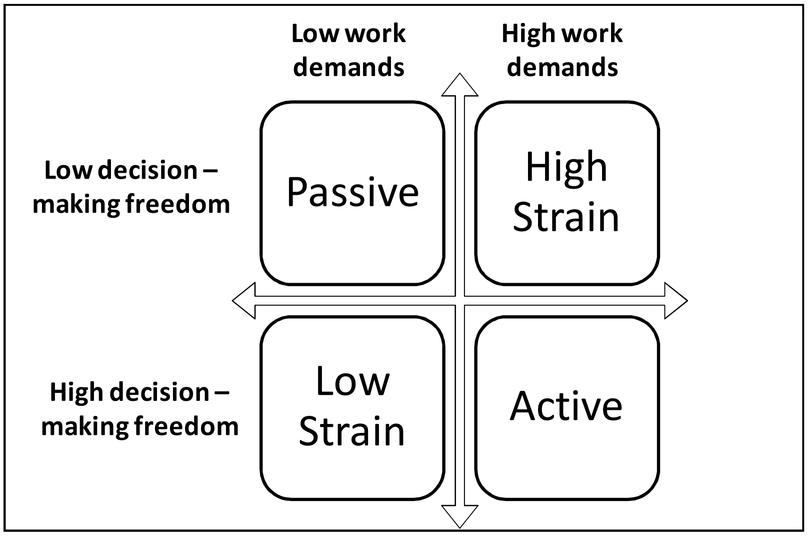


Figure 2.2 The Demand-Control Perspective (adapted from Kasasek, 1979)

With its emphasis on work demands and decision authority, the demand-control perspective focuses on objective elements of the task environment. For example, it seeks to explain on the basis of decision rights why executives and assembly-line workers show different levels of stress, although both could have stressful jobs. As such, the perspective explicitly ignores individual differences to maintain a focus on environmental and structural factors (Karasek, 1979). This purposeful masking of individual differences serves the perspective’s ultimate objective of deriving implications for the work environment, not personnel policy (Karasek, 1979). More specifically, the perspective’s major implication is that the stress resulting from high organizational output levels varies with the organizational decision structure. In the words of Karasek (1979, p. 288): “Strain equals the excess of demands over decision latitude.”

Two early studies by Karasek and colleagues were influential in supporting the demand-control perspective (Monat et al., 2007). Karasek et al. (1981) tested the link between certain work characteristics and cardiovascular disease in a random sample of male Swedish workers. Using multivariate logistic regression, they found that two measures of decision making-freedom are associated with cardiovascular disease. More specifically, while intellectual discretion was significantly and directly related to the disease measure, personal schedule freedom interacted with job demands to show a consistent but not significant relationship with the disease measure.

Another study by Karasek and colleagues (Alfredsson et al., 1982) tested whether elevated myocardial infarction risk is determined by certain characteristics of occupational groups. To this end, they identified all cases of myocardial infarction (including deaths) in men living in and around Stockholm, Sweden. The psychosocial characteristics of each of 118 occupations were recorded through survey responses collected from 3876 Swedish men. On this basis, relative risks of developing an infarct were computed for occupations in which many individuals reported a given characteristic compared to occupations in which few people reported given characteristics. The authors' results supported the hypothesis that such objective elements of the task environment as job decision authority interact with work demands to cause excess risk of developing a myocardial infarction.

The demand-control perspective has also been applied to IS phenomena. A search across more than 40 databases including Business Source Premier, which provides full text back to 1886 for over 2000 business journals, revealed one published study. Ahuja and Thatcher (2005) used the demand-control perspective to predict that autonomy (i.e., decision making-freedom) interacts with work overload to increase individuals' trying to innovate with IT. Applying partial least squares (PLS) analysis to perceptual data from 263 survey respondents, Ahuja and Thatcher found that the interaction between work demands and decision latitude interacts with gender to predict the extent to which individuals try to innovate with IT.

Additionally, Galluch (2009) used the demand-control perspective to predict that such facets of technostress as quantitative demand and demand variability lead to individual stress in the forms of perceived overload, feelings of ambiguity, and conflict. She further predicted that timing control extended to individuals (i.e., control over when to attend to interruptions), an objective element of the task environment in terms of decision authority, would weaken these relationships. Additionally, she proposed that such other objective elements of the task environment as extending method and resource control to individuals would reduce the manifestations of feelings of stress in physiological strain. In fully relying on objective elements of the task environment as demands and control mechanisms, Galluch (2009) maintained complete consistency with the demand-control perspective, making full use of its predictive power. She conducted laboratory experiments to test her model and found most of her hypotheses supported.

Although the demand-control perspective has been used extensively across numerous disciplines, it is subject to controversy for two main and potentially related reasons. First, recent research is often unclear on what “control” means in the context of workplace demands (Siegrist, 1996). In fact, the meaning of the control construct depends on the study objectives and on the research tradition in which studies are rooted. The literature reveals at least three different approaches to defining control in the workplace (Parkes, 1989): (1) control as an objective attribute of the workplace, for example in terms of decision-making freedom, (2) control as a subjective assessment of the extent to which an individual can control his or her work situation, and (3) control as a high-level, general perception of a person about the extent to which he or she can control important outcomes of the work situation.

Second, research using the demand-control perspective has resulted in conflicting findings (Monat et al., 2007). This problem can potentially be explained with the approaches to defining control in terms of subjective assessments and perceptions. Since the demand-control perspective explicitly limits its concept of control to objective attributes of the task environment (Karasek, 1979; Kasl, 1989; Siegrist, 1996), defining control in terms of subjective assessments and perceptions of the individual may be inconsistent with the perspective. In that vein, only the first of the three described approaches to defining control in the workplace may be consistent with the perspective, implying that the results obtained from this approach may well deviate from those obtained from the other two approaches.

Using the demand-control perspective to examine the role of adult age in a model of stress is particularly problematic (Kasl, 1989). As employees grow older, they become far less likely to work in occupations characterized as ‘high-strain’ by the demand-control perspective (i.e., high work demands and low decision-making freedom) (Kasl, 1989). Accordingly, the demand-control perspective has limited relevance for older adults. Furthermore, decision authority within jobs generally increases with adult age (Kasl, 1989), implying that the demand-control perspective may even confound age with control.

Consequently, the demand-control perspective may not be optimal to guide the development of a research model concerned with adult age, individual performance on computer-based tasks, and individual coping. The perspective explicitly ignores such individual differences as adult age (Karasek, 1979), implying that incorporating age in a research model guided by the demand-control perspective is inconsistent with the theory and may yield misleading results. Further, the demand-control perspective may have limited implications for older individuals and may even confound age with control effects (Kasl, 1989). Moreover, the perspective is concerned with worker health and, thus, does not specify the role of individual task performance in a model of stress (Karasek, 1979; Siegrist, 1996). Finally, the concept of coping is underdeveloped in the demand-control perspective since the perspective focuses on such organizational moderators as decision structure, not individual ones (Karasek, 1979). Individual coping as viewed by the demand-control perspective is largely passive; people cope with stress by having been extended decision authority.

2.2.1.2 Person-Environment Fit Perspective on Stress

The Person-Environment Fit perspective (P-E Fit; Pervin, 1968; French et al., 1982) generally suggests that all aspects of behavior and performance result from the perceived transaction or interaction between an individual and such environments as the workplace. The perspective is concerned with subjective evaluations of fit between a person and her workplace in terms of abilities and skills. Whereas an improved perceived fit is associated with less strain and higher performance, a perceived misfit results in poor performance and stress for the employee. The extent of fit or misfit is determined by a "relative balance of forces" between such environmental demands as workload and an individual's resources (e.g., time or such mental resources as thinking, calculating, remembering, and deciding) available for responding to these demands (Lazarus, 1999, p. 58). This weighing scale is analogous to a seesaw, with the environmental resource demand (i.e., an external force or stressor, such as workload) on one side of the seesaw and available resources on the other side (see Figure 2.3). As the environmental demand for such resources as time or thinking exceeds the available resources, implying a perceived mismatch between resource demand and supply as in the case of excessive workload, stress results (Lazarus, 1999) and performance declines (Pervin, 1968).

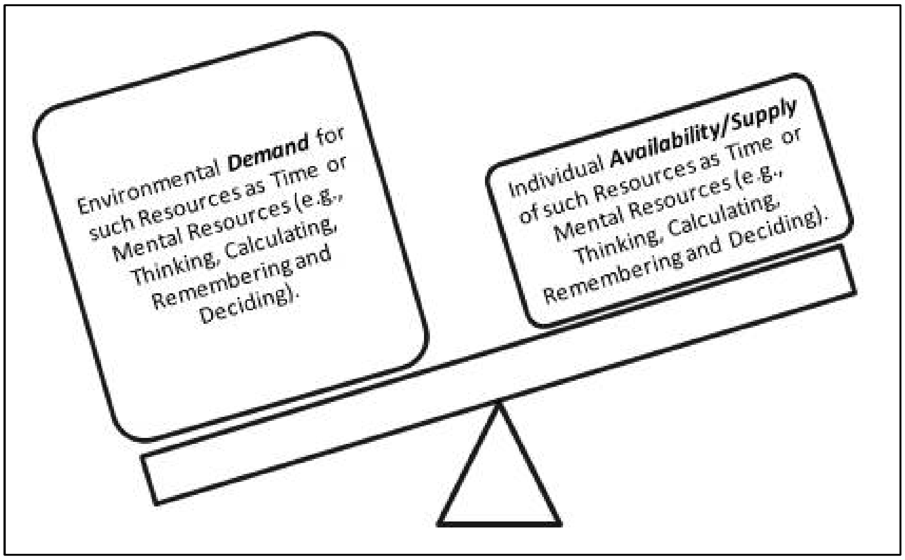


Figure 2.3 A high-stress balance (Lazarus, 1999)

Two early studies by French and colleagues were influential in supporting the P-E Fit perspective (Caplan & Harrison, 1993). French et al. (1974) presented a quantitative approach to conceptualizing the relationships among certain mental health factors. In the process, they developed measures of P-E Fit along ten dimensions, such as intelligence, which were thought to be important to the sample of 2,000 male high school attendants. Using correlation analysis, the authors found that perceived P-E Fit is significantly related to such negative affective states as anxiety, as well as to the respondents' likelihood of dropping out of school.

Another study by French and his colleagues (French et al., 1982) examined the effects of stressors in the task environment, and such perceptions of P-E misfit as high workload, on psychological and physiological stress. The authors administered a large-scale survey to 2010 men working in 23 different occupations. Using multiple regression analysis, they found strong support for P-E Fit theory, indicating that environmental stressors affect stress indirectly through their effects on perceptions of P-E Fit.

The P-E Fit perspective has also been applied to IS phenomena. A search across more than 40 databases including Business Source Premier revealed one published study. Chilton et al. (2005) used the P-E Fit perspective to examine cognitive style as a potential determinant of job stress and productivity impediments in software developers. Applying multiple regression analysis to survey data from 123 software developers, Chilton et al. found that stress increases and performance decreases as the fit between the preferred cognitive style of a software developer and the developer's perception of the style required by the task diminishes.

Additionally, a study by Ayyagari et al. (forthcoming), used the P-E Fit perspective to examine technological antecedents to and implications of technostress. The authors predicted that such technology characteristics as usability, intrusiveness, and dynamism would affect stress indirectly through their impact on P-E Fit, for example, in the form of work overload. Using field data from 661 working professionals, they found most of their hypotheses supported. In particular, they found that intrusive technology characteristics are the dominant predictors of P-E Fit in the context of technostress. The authors concluded that their study provides important evidence for the mediating role of P-E Fit in the relationship between technology and individual stress, and they suggest that future research may utilize the P-E Fit perspective to explore the stressful effects of such specific forms of technology as T-M interruptions.

While most theories based on the P-E fit perspective suggest that excess resource demands give rise to stress (see McGrath, 1976, for an exception), they are inconclusive on the role of excess resource supplies (Edwards, 1996). Some suggest that excess supplies create boredom and fatigue and thereby lead to stress (Beehr, 1995), whereas others indicate that excess supplies have no relationship with stress (Edwards, 1996).

Figure 2.4 presents the P-E fit perspective adapted from Warburton (1979). Consistent with ICT-based tasks, which place particularly high mental demands on individuals (Birdi & Zapf, 1997; Czaja & Sharit, 1993), the perspective views person-environment fit as a function of mental load (i.e., the ratio of cognitive resource supply to resource demand). This mental load (or cognitive load) arises from task demands, which are conceptualized in terms of environmental demands per unit time (Warburton, 1979). In other words, a person's mental load is determined by the frequency with which environmental demands occur. For example, as demands such as T-M interruptions occur more frequently, a person has to decide more frequently about whether to attend to an interruption and has to think more frequently about the content of an interruption, thereby incurring greater mental load within a given time period. This mental load, in turn, impacts stress. Consistent with much research in the area of organizational stress (e.g., Baynes et al., 1978; Beehr, 1995), the perspective further suggests that stress results in reduced task performance (Blau, 1981). A recent meta-analysis (Chang et al., 2009) verified that psychological strain intervenes between stressors and task performance.

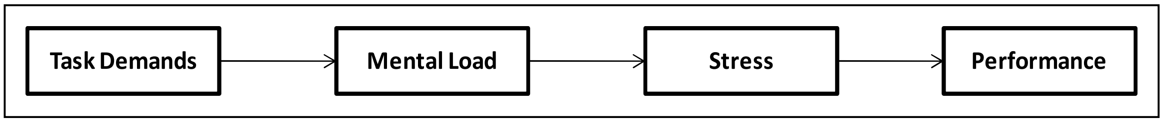


Figure 2.4 The Person-Environment fit perspective (Warburton, 1979)

The essence of P-E Fit is captured by perceptions of mental workload (Kaldenberg & Becker, 1992), a construct, which reflects the perceived relative balance between the mental resources required to perform the current task and the mental resources available (Hart & Staveland, 1988; Wickens et al., 2004). As such, perceived mental workload increases in correspondence with cognitive demands (Strayer & Drews, 2007; Yeh & Wickens, 1988). Research generally reports that work overload is associated with stress (Kaldenberg & Becker, 1992). In fact, a high level of perceived mental workload is a stressor of “particular importance” (Endsley, 1995, p. 53; Hart & Staveland, 1988) since it is directly associated with the threat of low performance.

Since the PE-fit perspective is a relational approach that considers the person and focuses on perceptions of fit, it gives “full recognition to individual differences” (Blau, 1981, p. 280; Lazarus, 1999). This is especially true since the perspective focuses on cognitive resources, which constitute a central avenue for explaining individual differences in stress responses (Warburton, 1979). Accordingly, the perspective allows for addressing differences in stress responses on the basis of cognitive aging, which refers to age-related changes in the availability of cognitive resources (Park, 2000).

In line with its suitability for addressing individual differences and relatedness to Lazarus (1966; 1999), the perspective also acknowledges the importance of coping (i.e., dealing with stressful events) (Harrison, 1985). Coping can be integrated into the model as a moderator of the P-E Fit–Stress link (Lazarus, 1999). In other words, coping can weaken effects of such stressors as perceived mental workload on stress. However, the question remains of what theoretical perspective should be used to examine the role of age in a theory of technostress.

2.2.1.3 Comparison of Theoretical Perspectives

The P-E Fit and Demand-Control perspectives have some characteristics in common. Most importantly, they both view stress as a transactional process, where stress results from the interaction between an individual and the environment. Furthermore, they focus on negative encounters, where stress results from excessive workplace demands.

Despite these commonalities, the perspectives depart in three aspects of prime importance for this research (see Table 2.1): (1) the treatment of individual differences, age in particular, (2) the specification of the role of task performance, and (3) the specification of the role of coping. These three aspects are important for this particular study for three reasons: this research is deeply concerned with age, an individual difference variable, attempts to explain the task performance implications of technostress, and attempts to explore the role of CSE as a potential coping mechanism.

First, while both perspectives are transactional, the Demand-Control model does not focus on the individual per se, but on the organizational context that surrounds the individual. The perspective is purposefully and explicitly environmentally-based. As such, it masks individual differences and may lead to incorrect results if control were defined in terms of such differences. Further, the perspective may yield very limited implications for older adults and may even confound age with control effects. By contrast, the P-E Fit perspective fully recognizes individual differences in stress responses. The perspective takes a relational approach and focuses on individual perceptions and cognitive resources, which constitute a central avenue for explaining individual differences in stress responses, particularly in the context of cognitive aging.

Criterion / Perspective	**Person-Environment Fit**		**Demand-Control**	
	CM	**Explanation**	***CM***	**Explanation**
Stressful encounter	**n/a**	Perceived misfit between resource supply and demand.	**n/a**	Interaction between work demands and organizational moderators, which represent forms of control in terms of decision authority extended to employees (e.g., personal schedule freedom).
Individual Differences are explicitly acknowledged	✓	The perspective takes a relational approach and focuses on individuals' perceptions of misfit. Further, it emphasizes cognitive resources, which constitute a central avenue for explaining individual differences in stress responses, particularly in the context of cognitive aging. In sum, the perspective "gives full recognition to individual differences" (Blau, 1981, p. 280).	☒	The perspective focuses on objective elements, such as decision authority. It purposefully masks individual differences. The perspective is sub-optimal with regard to adult age in particular. Hence, using it to address such individual differences as age in a model of technostress may result in incorrect findings.
Task Performance is explicitly acknowledged	✓	Task performance suffers as a function of stress.	☒	Not specified.
Individual Coping is explicitly acknowledged	✓	Coping can be integrated into the model as a moderator of the P-E Fit–Stress link.	☒	Acknowledged, but underdeveloped since the model focues on organizational moderators, not individual ones. Individual coping is passive: people cope by having been extended decision authority.

Legend: CM = Criterion met; n/a = not applicable.

Table 2.1 Comparison of Prominent Transactional Perspectives

Second, while the Demand-Control perspective is concerned with worker health and remains relatively silent on the issue of task performance, the P-E Fit perspective explicitly discusses task performance as a function of stress. Finally, the concept of individual coping is underdeveloped within the Demand-Control perspective, which is concerned with objective elements of the work environment and purposefully ignores individual-level variables. By contrast, coping is explicitly discussed within the P-E Fit perspective, which focuses on the person and is concerned with measures the individual can take to deal with stressful encounters.

On the basis of this comparison, the P-E Fit perspective is optimal to guide the development of our research model. It allows us to study the roles of adult age, task performance, and coping behaviors in a model of technostress. By contrast, the demand-control model is sub-optimal as it does not adequately specify these elements. We conclude that the P-E Fit perspective is the most appropriate one to guide the development of a research model that integrates the concepts of aging, stress, and task performance with T-M interruptions. But what exactly are these interruptions and how do they generate stress within the P-E Fit framework?

2.2.2 TECHNOLOGY-MEDIATED INTERRUPTIONS AS STRESS GENERATORS

While technology has many undisputed benefits for organizations and can reduce knowledge workers' experiences of stress by making required information readily available, facilitating decision making, and enabling more flexible work schedules (Ragu-Nathan et al., 2008), it has also increased the number of workplace interruptions, a counterproductive side effect. In potentially overloading individuals' attentive capacity (Meyer & Kieras, 1997; Tarafdar et al., 2007), these interruptions often lead to stress in individuals alongside reductions in workplace performance (Riemer & Frößler, 2007; Stephens, 2007).

An interruption refers to “any *distraction* that shifts individuals’ *attention* away from a current task and requires conscious effort to return to the original task” (Galluch, 2009, p. 34, citing Damrad-Frye & Lairs, 1989, and Jett & George, 2003). Accordingly, we define a T-M interruption as a distracting stimulus mediated through ICTs that interrupts individuals’ focused attention on the current task and requires conscious effort to return to the original task. Examples of T-M interruptions include unexpected email, instant messages, or video conferencing.

Recent research has indicated that T-M interruptions can increase stress in individuals. A comprehensive literature search across more than 40 databases including the proceedings of the conferences of the Association for Information Systems revealed two published studies and one doctoral dissertation that shed light on interruption-based technostress. First of all, Basoglu and Fuller (2007, p. 2), who define interruptions as “uncontrollable, unpredictable stressors that produce information overload,” suggest that T-M interruptions result in stress for individuals. The authors propose a laboratory experiment with 250 subjects from a large northwestern university to test their model, which is consistent with the P-E Fit perspective. Their model indicates that T-M interruptions do not affect such interruption outcomes as stress directly, but rather give rise to cognitive load. Cognitive load, in turn, results in negative interruption outcomes, such as slowed task progress and reduced accuracy in task performance. Similarly, through a case study of a hospital’s operating room practices, Ren et al. (2008) found that T-M interruptions can lead to stress in individuals by causing delays and potentially breaking peoples’ concentration on the current task. These two studies may have laid the foundations for advanced research on T-M interruptions, and were elaborated upon by a more recent study.

More recently, Galluch (2009) examined whether T-M interruptions can break the concentration of individuals on the current task, thereby leading to stress. By using the Demand and Control perspective and conducting two experiments, she found that quantitative demand associated with T-M interruptions increases perceptions of stress, and that this relationship is moderated by peoples’ decision-making freedom. When individuals could decide when to attend to the interruption, the quanititative demand–stress relationship was weaker. She also found that an instant message that supports the current task has a different effect on stress than an off-task message. Further, using alpha-amylase found in saliva to evaluate physiological strain, she found that extending method and resource control to individuals weakens the manifestation of stress perceptions in strain.

Overall, while little research has examined the role of T-M interruptions in the technostress phenomenon, it has consistently viewed these interruptions as problematic, and although the literature is unclear on whether to model the effects of T-M interruptions on stress as direct (Galluch, 2009) or indirect (Basoglu & Fuller, 2007), it converges on the idea that these interruptions lead to stress by breaking individuals’ concentration on the current task (see Table 2.2). This view suggests that human cognition in general, and sustained attention in particular, plays a major role in intervening between T-M interruptions and such interruption outcomes as individual stress. This is consistent with the P-E Fit perspective, suggesting that T-M interruptions may affect stress indirectly through their impact on P-E Fit in the form of individuals' perceived mental workload.

Source	**Effect type**	**Mechanism connecting T-M interruptions and stress**	**Connecting mechanism consistent with the P-E Fit perspective?**
Basoglu & Fuller (2007)	Indirect	Cognitive Load	Yes, cognitive load is related to resource supply and is similar to the concept of mental workload. Further, it intervenes in the relationship between interruptions and stress
Ren et al. (2008)	n/a	Sustained attention	Yes, sustained attention difficulties arise from an imbalance of resource supply and demand and intervene in the relationship between interruptions and stress
Galluch (2009)	Direct	Breaks in the concentration on another task	Yes, concentration breaks in response to excessive resource demands, and these breaks in concentration intervene in the relationship between interruptions and stress

Legend: n/a = not applicable because no prediction was made.

Table 2.2 Treatment of T-M interruptions in the Technostress literature

The question remains of whether these interruptions affect older compared to younger people differently. The next section reviews research that discusses the role of age in the stress phenomenon in general and in technostress in particular.

2.2.3 THE ROLE OF AGE IN STRESS RESEARCH

Although peoples' feelings and behaviors are shaped by culture and social structure, they are not entirely homogeneous. While people share a social identity, they also have private identities, leading them to construct social reality in different ways (Lazarus, 1966). Thus, individual differences are important for understanding differences in individuals' responses to such external stimuli as workplace stressors (Lazarus, 1966). Two basic principles are involved in individual stress responses: (1) individuals share some characteristics and behaviors, and (2) extensive individual differences always remain (Lazarus, 1966). This implies that evaluating main effects of workplace stressors does not suffice; research also needs to examine the extent to which stress responses vary across persons, what specific individual differences explain this variation, and why stress responses vary with specific individual differences (Kahn & Byosiere, 1992).

Individual differences can moderate stress at different links in the causal sequence from an external stressor to the consequences of stress (Kahn & Byosiere, 1992). They can occur between a stressor and an individual's perception of the stressor (i.e., P-E fit) as well as between that perception and subsequent experiences of stress (see Figure 2.5).

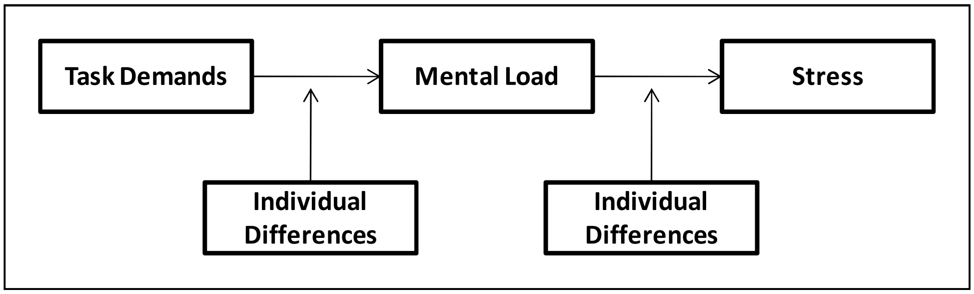


Figure 2.5 Moderating Influences of Individual Differences

Age is an important individual difference to consider in the context of workplace stress since the population historically associated with retirement (i.e., people over 65) constitutes the fastest growing part of the U.S. workforce (Howell, 1997; Panek, 1997), and there is some evidence that older individuals differ from younger in their responses to stressors (Neupert et al., 2006; Uchino et al., 2006). Further, divergent life histories constitute a main reason for the mere existence of individual differences (Lazarus, 1966). As people grow older, life histories are becoming longer and gain greater potential to diverge from the experiences of younger adults.

Despite the importance of studying differences in stress responses across older and younger individuals, limited research has examined such differences in responses to stressors in general, and to workplace stressors in particular. Typically, stress research examines the concept of age with a focus on stressful events specific to old age, such as death of a spouse, chronic illnesses, or loneliness (e.g., Lazarus, 1998; 1999), not with a focus on age differences in stress responses. However, there are exceptions. Neupert et al. (2006) conducted an experiment with 74 participants to test the interaction effect between cognitive challenge and age on physiological stress. Cognitive challenge was measured by vocabulary, short-term working memory, speed, and reasoning tests. Participant age ranged from 25 to 74 years. Stress was measured through salivary cortisol levels. Consistent with the ideas advanced by the P-E fit perspective, the authors found that age was positively associated with physiological stress responses under the condition of cognitive challenge. This suggests that age may interact with the mental workload perceptions potentially arising from T-M interruptions to influence technostress. However, Neupert et al. (2006) did not apply a theory of aging to predict age effects and interpret the findings.

Similarly, Uchino et al. (2006) conducted an experiment with 214 participants to test the interaction effect between daily hassles and age on physiological stress as measured by ambulatory blood pressure. They found that older people experienced significantly larger increases in blood pressure than younger adults when dealing with daily stressors. Since T-M interruptions are a form of daily stressors, Uchino et al.'s (2006) findings suggest for this study that older people may experience more technostress due to T-M interruptions than younger. Like Neupert et al. (2006), Uchino et al. (2006) did not use a theory of aging.

Research examining age differences in individuals' responses to technological stressors is particularly limited. A comprehensive literature search across more than 40 databases revealed five published studies, only three of which included age as a substantive variable (see Table 2.3). While studies in the technostress context consistently found that age differences in stress responses exist, their findings were contradictory. Some studies (Czaja et al., 1998; Ragu-Nathan et al., 2008) found that technostress decreases as age increases, whereas others (Sharit et al., 1998; Tu et al., 2005; Wang et al., 2008) found that the opposite is true. Similarly, perhaps as a result of their weak theoretical justifications, several studies' findings contradicted the studies' predictions (Czaja et al. 1998; Ragu-Nathan et al., 2008; Sharit et al., 1998). Relatedly, the extant literature examines age differences in stress responses in an atheoretical fashion, implying that none of these five studies applied a theory of aging to predict age effects in the technostress context and interpret the findings.

To illustrate, consider the only two studies in this context that appeared in IS journals. Using the Transaction-Based Model of Stress, which does not address age-related differences, as their overarching theoretical frame, Ragu-Nathan et al. (2008) hypothesized that older and younger peoples' experiences of technostress are the same. Applying structural equation modeling (SEM) to 608 survey responses from end users of ICTs, Ragu-Nathan et al. found that – inconsistent with their hypothesis – technostress decreased with age. They explained this finding with the possibly longer organizational tenure of older employees that may result in more firm-specific experience and an improved understanding of how to assimilate the effects of ICTs. The authors further suggest that their finding with regard to age effects may be sample-specific. Please note that Ragu-Nathan et al. (2008) did not apply a theory of aging to derive their age-related prediction and understand their finding, potentially explaining why their finding (a negative relationship) was inconsistent with their prediction (no relationship).

Using no theory at all, another study by Tu et al. (2005) examined technostress in China motivated by the problem that Chinese employees are often overwhelmed by modern ICTs. The authors found that technostress increases with age, and they explained this finding with the idea that older individuals often think more rigidly than younger people and more strongly "stick" to conventional work environments and procedures. As a result of older adults' greater resistance to change, technological stressors may challenge older people more than younger individuals. Tu et al. further suggest that individuals' ability to learn often decreases with age. Please note that the authors did not apply a theory of aging to understand their findings. Further, Tu et al.'s findings regarding age-effects contradicted those obtained by Ragu-Nathan et al. (2005).

The contradictions within and across these studies, along with the atheoretical nature with which these studies treat the concept of age, are largely a function of our immaturity in this topic (Huber, 1983). As a result of this immaturity, recent research (Tarafdar et al., 2007) called for an examination of the role of age in technostress. Research investigating the role of age in this context could leverage the theories of cognitive aging provided by Psychology research. For example, since research on T-M interruptions consistently indicates that interruptions result in stress by breaking peoples' concentration on the current task, research in this area could apply the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988) to understand the role of adult age. This theory is a major theoretical approach to aging (McDowd & Shaw, 2000; Smith, 1996), which indicates that older individuals are more vulnerable to distraction than younger people due to their impaired ability to actively disregard distracting stimuli. The theory may suggest that older people potentially face more trouble in disregarding T-M interruptions, thereby experiencing more breaks in their concentration, and subsequently more technostress.

Source	Treatment of age	Theories Used	Prediction	Theoretical Justification	Findings	Explanation of Findings	Atheoretical re Age	Within-study contradiction	Cross-study contradiction
Czaja et al. (1998)	Substantive variable	None	Older compared to younger people experience more technostress	None	Technostress decreases with age	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	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 further note that this result could be sample-specific.	✓	✓	
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 less mentally challenging and more socially interactive tasks, but increases with age for more mentally challenging tasks.	Declines in such cognitive abilities as working memory can make older compared to younger people more vulnerable to mentally challenging tasks.	✓	✓	**Technostress increases with age**
Tu et al. (2005)	n/a	None	n/a	n/a	Technostress increases with age	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 resisitance to change. Also, learning capacity can decrease with age.	✓	**n/a**	
Wang et al. (2008)	Control variable	None	n/a	n/a	Technostress increases with age	None	✓	**n/a**	

Legend: n/a = not applicable because no prediction was made; within-study contradiction = contradiction between a study's prediction and findings.

Table 2.3 Treatment of Age in the Technostress literature

Examining the role of adult age in the technostress domain is not only important to understand when or for whom ICTs impose threats, but also to understand whether older adults cope more or less effectively than younger people with such stressors as ICTs (Lazarus, 1966). To advance understanding of age-related differences in coping with T-M interruptions, the next section examines the potential of computer self-efficacy to serve as a coping mechanism. Later sections will return to computer self-efficacy to examine its relationship with adult age.

2.2.4 CONFIDENCE: COMPUTER SELF-EFFICACY AS A COPING MECHANISM

Coping refers to peoples' cognitive efforts to manage specific environmental demands that are perceived as exceeding their cognitive resources (Lazarus & Folkman, 1984). Coping with demand stressors can be viewed as reciprocal to stress, such that individuals experience lower levels of stress in the case of effective coping with the stressor, and higher levels of stress in the case of ineffective coping with the stressor (Lazarus, 1999). Thus, when people manage the threat arising from a stressor effectively, the stressor is less likely to manifest itself in individual stress. As such, coping is an integral part of the stress process that should complement any study of individual stress (Lazarus, 1999).

Within the person-environment fit perspective, coping reduces the impact of such perceptions of P-E misfit as perceived mental workload on individual stress (Van Harrison, 1985; Lazarus, 1999). More specifically, when people can cope effectively with mental workload perceptions, these perceptions are less likely to manifest themselves in stress. The opposite is true in case people cannot cope effectively with mental workload perceptions. Accordingly, coping can be integrated into the P-E Fit perspective as a moderator weakening the effect of mental workload perceptions on stress (see Figure 2.6). However, coping effectiveness may differ between younger and older individuals.

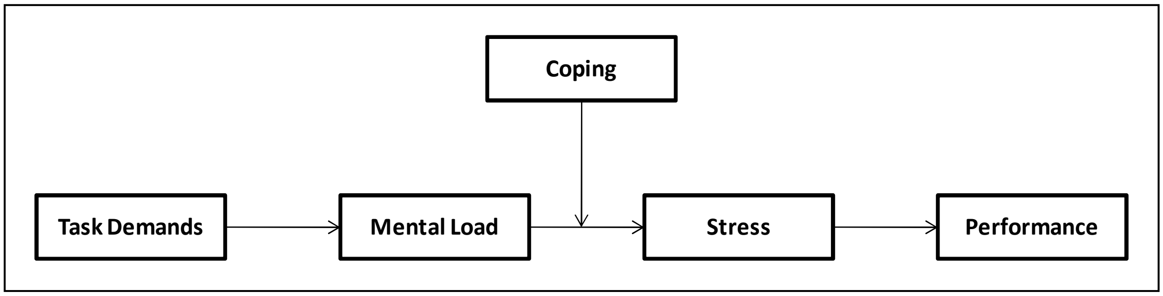


Figure 2.6 Coping within the Person-Environment fit perspective

Recent research revealed that older and younger people cope differently (Amirkhan & Auyeung, 2007; Nicholls et al., 2009; Wadsworth et al., 2004). This research indicates that coping differences arise from differing extents of coping resources available to people of different age groups (see Figure 2.7). For instance, older compared to younger individuals may be less able to rely on social support for coping since people of old age tend to have low levels of companionship (Suls & Mullen, 1982). In this example, coping differences on the basis of social support exist because older people possess a lower level of this coping resource than younger individuals do. Hence, age differences in coping manifest themselves in the availability of coping resources. Due to the pertinence of specific coping resources to the coping process, the concept of coping needs to be concretized in terms of such specific resources as beliefs (Lazarus & Folkman, 1984).

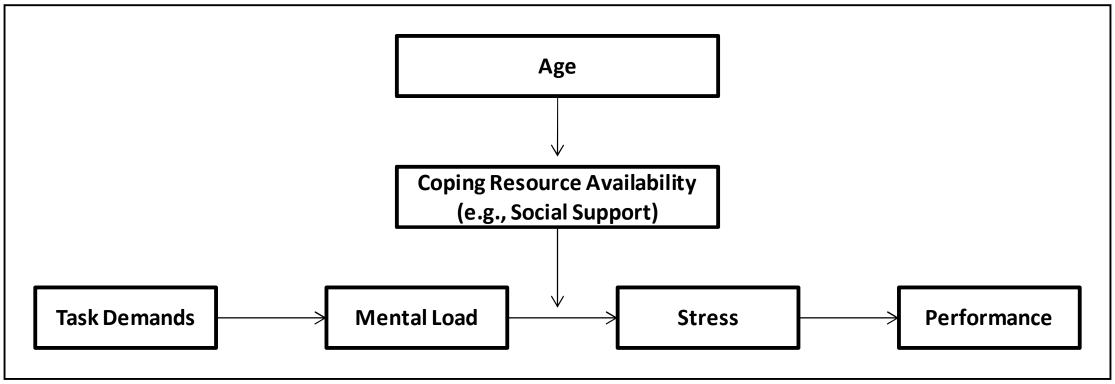


Figure 2.7 Manifestation of Age-related Differences in Coping

Individuals' belief systems, such as self-efficacy beliefs, are major factors in coping (Bandura, 1982; 1997; Lazarus, 1999). Self-efficacy refers to the extent to which individuals believe in their ability to do what is required to meet task demands (Bandura, 1986; 1989). As such, it is a form of cognitive coping, implying that it generates positive thoughts that influence stress by altering the cognitive interpretation of the person-environment relationship (Bandura, 1989; Lazarus, 1999). In stressful situations, individuals with a high sense of self-efficacy visualize success scenarios that positively guide behavior performance. By contrast, people with a low sense of 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). Thus, stronger compared to weaker self-efficacy beliefs imply that demands can more easily be met and present less of a struggle (Bandura, 1997; Lazarus, 1999).

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 implies that self-efficacy per se does not have a linear relationship with individual stress. Rather, 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 self-efficacy only matters in a stressful context. More specifically, *when* individuals 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), that is, it is the interaction between self-efficacy and a stressor that affects stress.

Computer Self-efficacy (CSE) as individuals’ beliefs about their ability to use computers in service of accomplishing work tasks (Compeau & Higgins, 1995; Marakas et al., 1998; Thatcher et al., 2008) may hence weaken stressor-stress relationships, implying that CSE interacts with such stressors as mental workload perceptions to impact individual stress. Since adult age is an important and “*known antecedent”* to CSE (Marakas et al., 1998, p. 149), which, in turn, is an integral part of the stress process (Lazarus, 1999), CSE is pertinent to the study of age-related differences in technostress. More specifically, since older people tend to have lower CSE than younger adults (Czaja et al., 2006; Marakas et al., 1998), their coping effectiveness on the basis of CSE should be lower. However, little research has examined CSE’s relation with technostress, let alone age-related differences in technostress on the basis of CSE.

A comprehensive literature search revealed one paper that examined CSE's relationship with technostress. On the premise that CSE reduces computer anxiety (Compeau & Higgins, 1995; Thatcher & Perrewe, 2002; Thatcher et al., 2008), Ragu-Nathan et al. (2008) predicted and found that CSE has a direct negative relationship with such technostress creators as technological complexity. While this finding is encouraging and suggests that CSE may indeed play an important role in a theory of technostress, it does not get at the idea of CSE as a coping mechanism. The role of CSE in a theory of technostress may be more complex than a simple direct effect of CSE on perceptions on technological complexity would suggest. Further, CSE was superficially included in Ragu-Nathan et al.'s study, without an adequate theoretical explanation of its relationship with technological stressors. Hence, more work is needed to deepen understanding of the construct's role in the technostress phenomenon.

2.2.5 SECTION SUMMARY

This review of the literature on individual stress yields several interesting insights for the development of a core model of technostress in the context of T-M interruptions. To begin with, contemporary stress research views the formation of stress as a transactional process (Hancock & Szalma, 2008; Lazarus, 1999). In accordance with this view, stress does not arise from a stressor per se, but from the interaction between a person and such environmental stressors as T-M interruptions. Our review of the two most prominent transactional perspectives reveals that the P-E Fit perspective, which assumes that stress arises from a perceived misfit between an individual's cognitive resources available for performing a task and those required (Lazarus, 1999), is the most appropriate theoretical framework for examining the role of age in a model of technostress. This perspective suggests that environmental demands (conceptualized in terms of frequency of occurrence or environmental demands per unit time) give rise to mental load (i.e., excess demand of cognitive resources), which in turn increases stress. As a function of this stress, individual task performance suffers (Warburton, 1979). The essence of P-E Fit is captured by the construct ‘perceived mental workload’ (Kaldenberg & Becker, 1992), which is the perceived ratio of the mental resources required to accomplish the current task to the resources available. Mental workload perceptions generally increase in correspondence with cognitive demands and are the stressor that ultimately generates stress (Wickens et al., 2004).

Consistent with the P-E Fit perspective, our review further indicates that the T-M interruption, a characteristic of the task environment, is unlikely to generate stress directly (Basoglu & Fuller, 2007; Warburton, 1979). Rather, perceptions of P-E Fit may intervene in the T-M interruption–Stress relationship since human cognition is generally believed to mediate the effects of T-M interruptions on such interruption outcomes as stress. However, precious little research has explored the role of T-M interruptions in the technostress phenomenon.

Similarly, only few studies have examined the role of age in technostress – and these studies have failed to use theoretical approaches to aging to predict age-related relationships and interpret the findings (e.g., Ragu-Nathan et al., 2008; Tu et al., 2005). Not surprisingly, results have been inconclusive, with some studies indicating that adult age gives rise to technostress (Sharit et al., 1998; Tu et al., 2005; Wang et al., 2008), and others suggesting that older compared to younger people experience less technostress (Czaja et al., 1998; Ragu-Nathan et al., 2008). Perhaps even more problematic, study findings contradicted study predictions within several papers. Accordingly, more work is needed to deepen understanding of the role of age in technostress, for example, by applying the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988) to the study of age-related differences in stress-responses to T-M interruptions and associated differences in individual task performance.

Likewise, research is needed to deepen understanding of the function of CSE in the technostress phenomenon, particularly as it relates to adult age. Little research has examined the role of CSE in the technostress context (e.g., Ragu-Nathan et al., 2008). Further, such research has explored CSE's function in a superficial manner – positing direct effects of CSE on technological stressors without adequate theoretical justifications. Based on the concept of coping, the role of CSE may be more complex than a simple direct effect on technological stressors would suggest. Further, CSE may impact older adults' experiences of technostress to a different extent than younger peoples' experiences of technostress since age is a "known antecedent" to CSE (Marakas et al., 1998, p. 149).

Figure 2.8 illustrates how our review of stress research frames a model of technostress in the context of T-M interruptions. The P-E Fit perspective provides the basic causal sequence connecting T-M interruptions to individual stress and task performance. In so doing, the perspective frames a core model of technostress. Combined with the literature on T-M interruptions, the P-E Fit perspective indicates that the frequency with which T-M interruptions appear gives rise to perceptions of person-environment misfit in the form of mental workload. This is because the P-E Fit perspective conceptualizes task demands in terms of environmental demands per unit time (i.e., frequency), and as demands such as T-M interruptions occur more frequently, a person will have to decide more frequently about whether to attend to an interruption (among other things) incurring greater mental workload within a given time period. Perceptions of mental workload, in turn, increase experiences of stress, which subsequently reduce individual performance on computer-based tasks. Our review further suggests that age and computer self-efficacy are important constructs to examine within the context of such technological stressors as T-M interruptions. Since age is an important antecedent to CSE, CSE may yield interesting insights regarding age-differences in technostress.

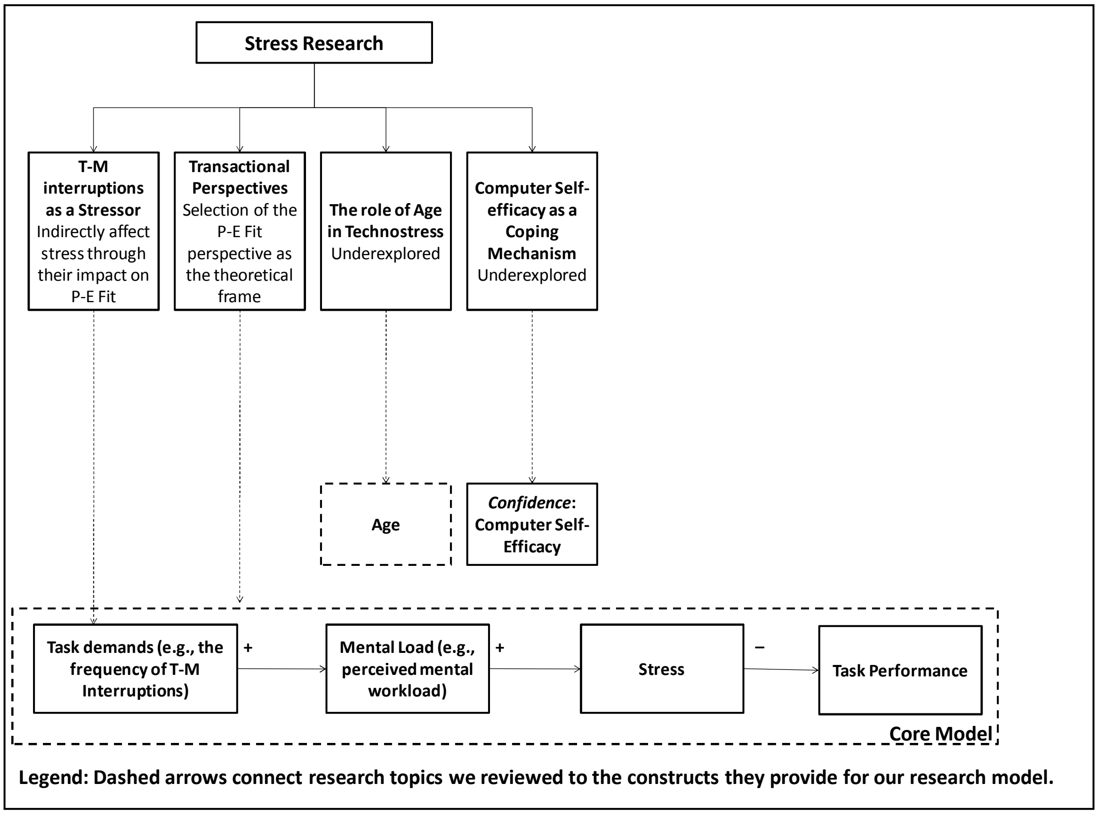


Figure 2.8 Illustration of how our review of stress research informs model development

This review of stress research also indicates that human cognition in general and focused attention in particular play a major role in interrelating core stress-related concepts. For this reason, and because cognitive abilities are often assumed to decline with age, the next section reviews the literature on selective attention. This will help us formulate a context for studying (1) how and why T-M interruptions may result in person-environment misfit in the form of mental workload perceptions, and (2) how and why older people may be differentially affected.

2.3 SELECTIVE ATTENTION

The previous section offered some insight into the core nomological network surrounding T-M interruptions, stress, and task performance. However, we still lack a deeper understanding of the relationship between T-M interruptions and person-environment misfit in the form of mental workload perceptions. Why exactly does this relationship exist and on what individual abilities does it depend? In this section we review selective attention theory to better understand how human cognition and focused attention are involved in linking these concepts.

2.3.1 OVERVIEW OF THE MECHANISMS OF SELECTIVE ATTENTION

Selective attention refers to individuals' ability to selectively process some information sources whole ignoring others (Strayer & Drews, 2007). To illustrate, consider the analogy of picking an apple from a tree that holds many apples (Neumann, 1987, p. 384). "There are probably a number of apples that my arm could reach (…). Obviously, I cannot grasp them all at the same time." People must select one apple at a time from all those that are visible. More generally, since individuals cannot simultaneously process all the stimuli that continuously bombard their senses, selective attention is necessary to ensure that the most relevant information is processed while less relevant information is excluded from receiving processing resources. As such, selective attention is concerned with the allocation of precious processing resources (Warburton, 1979).

To ensure an efficient allocation of processing resources, selective attention relies on two mechanisms: attentional inhibition and amplification (Houghton & Tipper, 1994). This aspect is referred to as the Dual-Opponent Mechanism of Selective Attention (Houghton & Tipper, 1994) (see Table 2.4), which postulates that inhibitory and amplificatory processes work concurrently to pull distracting and target stimuli apart. These processes are also referred to as a goal-directed (i.e., active and deliberate) top-down attentional mechanism and a stimulus-driven bottom-up mechanism, respectively (Lorenzo-Lopez et al., 2008). While the inhibitory mechanism serves to unselect (i.e., dampen) irrelevant stimuli, the amplificatory mechanism serves to select relatively salient objects for receiving processing resources. Accordingly, the allocation of processing resources is driven by both the effectiveness of the inhibitory process and the salience of the stimulus. For instance, when shopping in a grocery store, people may be actively trying to disregard any information not related to the Oreo cookies they are looking for (goal-directed attention or inhibition); yet their attention may still be captured involuntarily by the flashing orange light next to the generic cookie (stimulus-driven attention or amplification) (Christ et al., 2008).

Mechanism	Purpose	Nature of effect	Metaphor	Example
Inhibition	Unselection of distracting objects	Top-down controlled (i.e., goal-directed and voluntary)	None	Active ignoring of any information not related to Oreo cookies
Amplification	Selection of relatively salient objects	Bottom-up triggered (i.e., stimulus-driven and involuntary)	Spotlight	Attentional capture by the generic cookie next to the flashing orange light

Table 2.4 The Dual-Opponent Mechanism of Selective Attention

While attentional inhibition and amplification work concurrently, they are also independent mechanisms of selective attention (Koelewijn et al., 2009). Hence, although it has intuitive appeal to think that the effect of inhibition may be weaker in the presence of greater object salience, it cannot be expected that the two mechanisms interact in allocating processing resources. In fact, recent research showed that there is stimulus-driven capture of visual attention by irrelevant aural and visual stimuli that goal-directed attentional control cannot inhibit (Koelewijn et al., 2009). Such research has shown that even when visual attention is completely focused to a specific visual field, aural or visual stimuli can still capture visual attention automatically (i.e., involuntarily) in a bottom-up fashion. Consistent with this empirical evidence, Yantis (1993a, p. 676) indicates that “certain properties of the stimulus may capture attention independently of the observer's goals and beliefs,” where goals and beliefs refer to inhibitory processes.

Similarly, Theeuwes (1991) hypothesizes that the selection of certain visual stimuli in a visual field over others depends on the relative salience of the stimuli. He indicates that irrespective of goal-directed attentional control (i.e., inhibition), a stimulus with high salience disrupts search for a less salient one. Theeuwes' (1992, p. 15) tested this hypothesis empirically and found strong support that, in fact, attentional inhibition and amplification operate independently; they do not interact: “even when subjects have a clear attentional set for a static discontinuity, a dynamic discontinuity interferes, and vice versa”. He concluded that an attentional set for a specific type of stimuli cannot inhibit the stimulus-driven capture of inconsistent types of stimuli, and vice versa. Instead, the control of attention can be purely stimulus-driven or goal-directed, implying that irrespective of goal-directed attentional control, visual attention is automatically and involuntary captured by the most salient stimulus. In other words, attentional responses to salient items cannot be inhibited, implying that an interaction between inhibition and amplification in allocating processing resources cannot be expected.

As elaborated upon below, when attentional inhibition is impaired or appearing stimuli are relatively salient, individuals become more vulnerable to distraction because more distracting stimuli can draw attention away from the current task. This leaves fewer mental resources for the processing of task-related information. Accordingly, attentional inhibition and distracter salience interact individually with the frequency with which distracters appear to reduce the attentional resources available for current task processing (Hasher & Zacks, 1988; Zacks & Hasher, 1997; Warburton, 1979).

2.3.1.1 Concentration: Inhibition as a Mechanism of Selective Attention

Inhibition enables individuals to actively disregard attentionally compelling, but irrelevant stimuli (Strayer & Drews, 2007). Consider the following example (Simons & Chabris, 1999): subjects watched a video clip showing two teams passing a ball back and forth. Subjects were asked to report how often the team wearing 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 the scene. Amazingly, as much as 58 percent of the participants did not see the gorilla! This example illustrates that the inhibition mechanism of selective attention can be very effective in filtering out highly salient, but irrelevant, stimuli.

However, the effectiveness of the inhibition mechanism varies greatly across individuals (Strayer & Drews, 2007). Researchers often examine this variation through the Stroop Color Word task (Stroop, 1935), which presents an excellent example of some individuals' potential inability to exclude irrelevant stimuli from receiving access to processing resources (Strayer & Drews, 2007). In this task, observers are presented with color word names printed in incongruent ink colors (e.g., the word BLUE printed in red ink) and have to name the ink color while ignoring the color word name. The performance on this task differs greatly across individuals, with many people performing quite poorly (Strayer & Drews, 2007), suggesting that such individual differences as age play an important role in inhibitory effectiveness.

2.3.1.2 Capture: Amplification as a Mechanism of Selective Attention

The amplification mechanism works on object salience, which refers to the extent to which an object or stimulus stands out from the visual scene in which it appears (Huang & Pashler, 2005). Objects stand out from a visual scene to the extent to which they are locally unique in some dimension, for example, a red object among gray ones (Yantis & Egeth, 1999). As stimuli become more salient, they are more likely to capture individuals' attention because the amplification mechanism automatically directs attention toward relatively salient information in such visual scenes as computer displays.

To illustrate, attentional amplification is often referred to as the "spotlight"-mechanism of selective attention (Houghton & Tipper, 1994, p. 59) since it acts as a spotlight to influence selective attention efficiency. Like the beam of a spotlight, it directs visual attention toward the relatively salient information in a display. As such, the amplification mechanism represents "how things appear to the conscious mind." Stimuli that appear in a relatively salient form elicit stimulus-driven capture of visual attention (Cole et al., 2003; Yantis & Egeth, 1999), meaning that they capture attention involuntarily in a bottom-up fashion (Escera & Corral, 2007). However, salience is an abstract theoretical concept. To better understand its nature and effects, it may be helpful to concretize salience in terms of specific features that operationally define the extent to which such objects as interruptions seem to “pop-out” of the display.

Object salience has three operational facets: color code, dynamism, and auditory alert (Strayer & Drews, 2007; Wickens et al., 2004). As elaborated upon below, objects that appear on a display in a reddish color, are dynamic as opposed to static, and whose appearance is accompanied by an aural alert, are particularly salient and hence effective in capturing attention. For example, police cars combine bright and flashing emergency lights with loud sirens. Closer examination of these three operational aspects is helpful to understand under what conditions T-M interruptions are particularly likely to capture individuals’ attention and lead to P-E misfit.

Color code refers to the color in which a stimulus appears in a visual scene. When the target information is highlighted in an appropriate color so that it seems to “pop out” of the display (i.e., it is highly salient), the search time is shorter (Fisher et al., 1989). Since some colors are more salient than others, color-coding is an effective attentional filtering method (Yeh & Wickens, 2001). In terms of color salience, researchers consistently find red to be the most salient, followed by orange, yellow, and green (e.g., Bayot et al., 2008; Luoma et al., 1997; Wickens et al., 2004). This coding scheme is also consistent with the color codes used by the American Aviation Community (Wickens et al., 2004) and the U.S. Department of Homeland Security[3] (Rivera et al., 2006). The distinction between red and green is particularly salient due to peoples' past experience with these colors in human-designed systems (e.g., traffic lights) (Wickens et al., 2004). Essentially, the more reddish the color of a stimulus, the more salient it is and the more attention it will capture. This also implies that green, white or other colors that are clearly discriminable from red, orange, and yellow, may generally function well to reduce the intrusiveness associated with appearing new objects (Wickens et al., 2004). Thus, if distracters appear in a non-intrusive color (e.g., green or white distracters are more beneficial than red ones), selective attention may be more efficient.

Two recent studies are prominent in supporting the effectiveness of color coding for attentional capture (Strayer & Drews, 2007). Yeh and Wickens (2001, p. 547) found that color coding is effective for marking pertinent information in electronic battlefield maps. Eighteen students (10 men and 8 women) participated in Yeh and Wickens' experiment, which required the participants to search for information on the maps and answer questions about the maps. Exemplar questions include "Is unit J in the northeast corner?" and "Is highway 18 in the east?" The results obtained from analysis of variance revealed that color coding significantly improved subjects' performance in accurately answering the questions.

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[3] The Department of Homeland Security has been using color codes since 2002. However, it has discontinued the color-coded Homeland Security Advisory System in 2011 in favor of the National Terrorism Advisory System (http://www.dhs.gov/files/programs/ntas.shtm). This replacement was made in an attempt to convey more detailed information about specifics threats (the new alerts include information in seven threat categories); color codes can heighten sensitivity but don't convey specific information about threats (http://www.dhs.gov/files/publications/ntas-questions-answers.shtm).

Another study (Remington et al., 2000) found that air traffic controllers notice traffic conflicts more quickly when the plane altitude is color-coded. The authors conducted an experiment that consisted of one practice day and four days of actual data collection. Four retired air traffic controllers participated in the experiment. Repeated measures analysis of variance showed a significant main effect for color coding of altitude.

A perhaps more interesting study was conducted by Luoma et al. (1997) in the context of operating automobiles. Sixteen participants performed a task that involved pressing a button immediately once brake lamps were turned on. Yellow or red turn signals were also shown, either alone or followed by the brake signals. Participants were instructed not to react to the turn signals. The results obtained by Luoma et al. (1997) showed that reaction times to brake signals were significantly longer when turn signals were switched on, thereby indicating that turn signal was a significant distracter. More importantly, the authors also found that the main effect for color was significant, meaning that reaction times were longer with red as opposed to yellow turn signals. Consistent with the research mentioned above, this implies that red distracters distract significantly more from the current task (i.e., breaking) than yellow distracters do.

Dynamism refers to the extent to which appearing objects are emphasized through flashing (Yantis & Jonides, 1990; Yantis, 1993b) or stimuli movement (McLeod et al., 1991; Franconeri & Simons, 2003) as opposed to static. To illustrate, consider an air traffic controller’s display, which uses flash coding to promptly pull attention to situations that require the controller’s immediate attention (Yuditsky et al., 2002). The flashing cursor on computer screens is another good example for the effectiveness of dynamic cues for directing users’ attention. Attention is directed to the location of the cursor, which draws attention away from other elements on the screen due to its salience (i.e., standing out of the static display). Flashing cursors are usually used for primary tasks, thereby aiding selective attention.

By contrast, when distracting information appears as a flashing stimulus or with movement, attention may be diverted away from the task at hand (Strayer & Drews, 2007, p. 35). For example, dynamic internet pop-up advertisements are an intrusive form of technology that “steals” attention from the processing of information related to the primary task. This is particularly true since such pop-ups often combine flashing and movement stimuli. The same is true for contemporary electronic billboards, which often combine flashing messages with objects that move along the roadway, thereby distracting automobile drivers.

To illustrate, consider the study conducted by Sagarin et al. (2003) in the context of internet advertising. The 343 participants in their experiments had to solve anagrams while being exposed to static versus dynamic advertisements. In the dynamic condition, the ads moved across the screen and became animated once subjects moved the mouse over them. Participants had to solve as many anagrams as possible within ten minutes; the number of anagrams solved served as a measure of distraction. The authors hypothesized that greater ad-induced distraction would result in less attention being allocated to solving anagrams, thereby leading to fewer anagrams being solved. More specifically, increased ad salience through ad dynamism and interactivity was predicted to increase distraction, thereby reducing the number of solved anagrams. Analysis of variance revealed that increased ad salience through dynamism and interactivity is indeed associated with greater distraction as measured by performance.

Finally, auditory alerts refer to the extent to which an appearing object is accompanied by sound effects. Aural alerts are highly salient and intrusive (Strayer & Drews, 2007; Wickens et al., 2004). For this reason, fire alarms are given by sirens. Recent research has shown that people engaged in visual tasks and instructed to ignore associated auditory stimuli perform substantially worse when distracting aural stimuli appear. These distraction effects are particularly large when unique environmental sounds (e.g., a doorbell or telephone ringing, or a glass breaking) randomly substitute for the standard sound (Escera & Corral, 2007).

The intrusive nature of auditory alerts can be illustrated with the Irrelevant Sound Effect (Jones & Macken, 1993). The irrelevant sound effect refers to the reduction in task performance when irrelevant sound is played during the performance of memory tasks. Although participants are being explicitly instructed to ignore the sound and are assured that the sounds’ content will not be tested, they still suffer significantly from disruption (Jones et al., 1999). In fact, even continuously presented and hence expected irrelevant sounds often remain salient, implying that the effectiveness of sounds in capturing attention does not taper off over time (Berti et al., 2004).

The degree of disruption varies with specific sound manipulations. For example, a sequence of various sounds produces more disruption than does a sequence of repeated sounds (Jones et al., 1999). Also, the location of the auditory source determines the degree of interference; irrelevant sound presented to the left ear produces more disruption than sound presented to the right ear or to both ears (Hadlington et al., 2004). However, the disruption level is neither determined by the meaning of the sound nor by the semantic similarity between distracters and memorized items. Likewise, the irrelevant sound effect is not sensitive to the distracters' sound level when a level between 40 and 76 dB(A) (i.e., between auditory and pain thresholds) is maintained (Bell & Buchner, 2007).

These diverse operational facets of salience often combine in contemporary T-M interruptions (Strayer & Drews, 2007). Consider the example of the Skype® Instant Messenger. With Skype activated, an individual working on a computer-based task can unexpectedly receive instant messages. In the current Skype version (i.e., 4.2.0.169), an incoming message appears with flashing and an aural alert in a reddish color (orange), thereby effectively combining these three operational aspects of salience to capture attention involuntarily. However, the question remains of why these relatively salient objects capture attention involuntarily.

Research concerned with visual search may provide an explanation of why salient objects are more likely than non-salient ones to capture attention (Cole et al., 2003). This explanation relates to the amount of information an object contains. As an object contains more information, constructing its visual representation requires more processing resources, which, in turn, require more attention. For example, because an object that moves across the display may contain more information than a non-moving one, constructing a visual representation of the former stimulus might require more attentional resources. More specifically, in contrast to visual representations of static objects, those of moving objects have to include the movement in addition to the actual object. Moving objects may hence contain more information and thus capture more attention.

2.3.2 COST: EXPERIENCE CAN REDUCE RESOURCE REQUIREMENTS

To fully integrate the role of adult age into a theory of technostress that rests on human cognition, we also need to look at computer experience as a factor that may reduce the requirements of a task for mental resources (Rogers & Fisk, 2001). The saying *practice makes perfect* captures this idea by implying that performance generally improves as individuals gain experience through routine behavior performance. While novices' behavior performance tends to be slow and effortful, experts' performance tends to be fast, effortless, and automatic (Strayer & Drews, 2007). For example, as people gain experience in operating automobiles, controlling the steering wheel or gas pedal becomes more effortless and automatic (Strayer & Drews, 2007).

As tasks become more automatic, they demand less mental resources. Hence, at high levels of automatism, distractions can draw mental resources away from the current task without disrupting task performance. This phenomenon can be explained with Cognitive Load Theory (Sweller, 1988, 1994). The theory indicates that performance is constrained by the capacity of mental resources, and that such conditions as T-M interruptions can lead to performance declines when they overload the available capacity. According to this model, human memory consists of rules or schemata that link related pieces of information. Experience refines and automates these schemata and in turn reduces the cognitive load. More specifically, practice gradually replaces resource-intense effortful processes used for task performance by more efficient automatic processes (Shiffrin & Schneider, 1977). Automatic processing occurs whenever a specific eliciting stimulus is present. It happens unconsciously and requires few mental resources, if at all (Rogers & Fisk, 2001).

A compelling alternative explanation for the capability of experience to reduce mental resource requirements is that it enables people to use their long-term memory as an extension of their short-term memory (Ericsson & Kintsch, 1995). In so doing, experience expands the availability of mental resources. A potentially related reason for the expansion of the capacity of mental resources with experience is that experience enables people to process larger chunks of incoming information (Liu et al., 2004). Experience also leads people to develop skills that help them manage competing demands for limited cognitive resources (Liu et al., 2004). In so doing, experience enables individuals to more effectively juggle simultaneous demands from the main task and distractions, for example, handling a computer-based task while simultaneously attending to such T-M interruptions as instant messages.

Despite the potential of experience to mitigate people’s stress responses to such technological stressors as T-M interruptions, no research to date has examined computer experience in the technostress context. This is surprising given that recent research (Tarafdar et al., 2007) called for an analysis of the role of computer experience in the technostress phenomenon. However, a few studies argued for and found relationships between computer experience and computer anxiety on the basis that “the more experienced you are, the less anxious” (Beckers and Schmidt, 2003, p. 786). Heinssen et al. (1987) found a negative association between computer experience and anxiety. The authors constructed a 20-item computer anxiety rating scale by exploring the affective, behavioral, and cognitive aspects of computer anxiety among 270 university students. Correlation analysis showed that higher levels of computer anxiety were associated with lower levels of computer experience.

Another study (Beckers and Schmidt, 2003, p. 793) also found that computer experience had a negative effect on computer anxiety. Using a 12-item scale to measure experience with such items as ’’I know how to install software on a computer’’ and ‘‘I know how to retrieve erased or ‘lost’ data on a computer’’, they conducted two studies that tested the association between computer experience and anxiety. The first study was based on 184 survey responses from first year psychology students. Structural equation modeling using EQS revealed good fit for a model in which computer experience unidirectionally influenced computer experience. The second study among 225 psychology students extended the findings from the first one by suggesting that the effect of computer experience on computer anxiety depends on gender.

Similarly, Bozionelos (2004) also suggested that computer experience should reduce computer anxiety. He employed a 10-item scale for experience in which students rated the frequency of their use of a wide range of computer products, such as software, hardware, and networking products. Items ranged from such common applications as word-processing software use and internet browser use to more advanced ones like programming languages. Survey data obtained from 267 university students supported his prediction.

The support found for the relationship between computer experience and computer anxiety is encouraging and suggests that computer experience may indeed play an important role in a theory of technostress. However, this relationship does not get at the idea that computer experience may serve as a mechanism to reduce the mental resource requirements of computer-based tasks. Hence, the role of computer experience in a theory of technostress may be more complex than a simple direct effect on computer anxiety would suggest. Further, such arguments as “the more experienced you are, the less anxious” are not overly compelling; they lack logical development. Thus, more conceptualization is needed to deepen understanding of the role of computer experience in the technostress phenomenon.

2.3.3 SECTION SUMMARY

This review of the literature on selective attention provides further insights for developing a model of technostress in the context of T-M interruptions and adult age. To begin with, the frequency with which distracters appear interacts with attentional inhibition and distracter salience to reduce the availability of mental resources for current task processing (Houghton & Tipper, 1994). Attentional inhibition increases selective attention efficiency by enabling people to actively disregard distracting stimuli, thereby effectively reducing the number of distractions that can gain access to mental resources (Strayer & Drews, 2007). By contrast, distracter salience as a combination of color-code, dynamism, and aural alerts, reduces selective attention efficiency by enabling distracters to capture attention in a bottom-up, stimulus-driven way. In so doing, stimuli salience increases the number of distractions that can gain access to mental resources (Lorenzo-Lopez et al., 2008; Strayer & Drews, 2007). As a result, attentional inhibition weakens the effect of the frequency with which distracters appear on the availability of mental resources for current task processing, while distracter salience strengthens this effect.

Our review also finds that experience can reduce the requirements of a task for mental resources (Rogers & Fisk, 2001). In consequence of high levels of experience, distractions can draw mental resources away from the current task without disrupting task performance. Not surprisingly, recent research (Tarafdar et al., 2007) has called for examining the role of computer experience in the technostress phenomenon. Yet, precious little such work has been conducted.

Figure 2.9 illustrates how our review of the literature on selective attention adds to the previously presented core model of technostress by providing additional constructs that can further explain the link connecting ICTs to technostress and task performance. The dual-opponent mechanism of selective attention (Houghton & Tipper, 1994) provides two constructs, the inhibitory effectiveness of individuals and the salience of T-M interruptions, which may interact with the frequency of T-M interruptions to increase perceptions of person-environment misfit in the form of mental workload. While the inhibitory mechanism may enable people to actively disregard appearing T-M interruptions, thereby effectively reducing the number of T-M interruptions that can give rise to perceptions of mental workload, the salience of T-M interruptions may have the opposite effect. As T-M interruptions become more salient by combining an intrusive color with dynamism and sound, they may become more likely to capture peoples' attention. In consequence, relatively salient T-M interruptions are more likely to give rise to perceptions of mental workload. Our review further suggests that computer experience is an important construct to examine within the context of T-M interruptions. When high levels of computer experience are present, T-M interruptions can potentially draw mental resources away from computer-based tasks without increasing perceptions of mental workload.

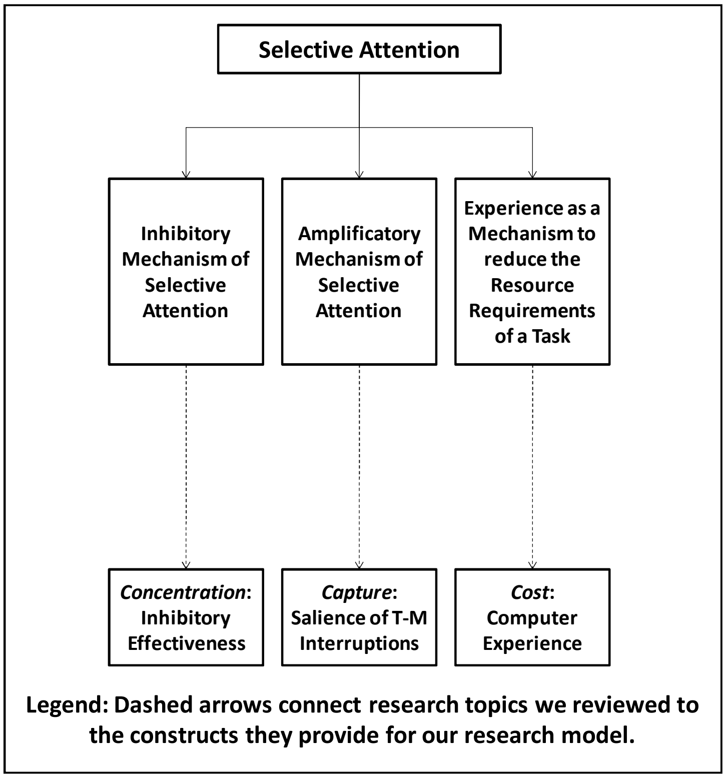

Figure 2.9 Illustration of how our review of the selective attention literature informs model development

As our earlier review of the P-E Fit perspective revealed, cognitive resources constitute a central avenue for explaining individual differences in stress responses (Warburton, 1979). Accordingly, the concepts reviewed in this section, all of which can impact the availability of mental resources for current task performance and all of which differ across individuals, lay the ground for reviewing age-related manifestations in a model of technostress. Hence, to formulate a context for studying how and why older people may be differentially affected by T-M interruptions, the next section reviews the literature on cognitive aging.

2.4 COGNITIVE AGING

The previous section offered further insight into the relationship between T-M interruptions and person-environment misfit in the form of mental workload perceptions. We found that the frequency with which distracters appear reduces the availability of mental resources for current task performance, and that this effect depends on such conditions as attentional inhibition, distracter salience, and experience. However, we still lack a deeper understanding of potential age-related manifestations in a model of technostress. How effectively do older people inhibit responses to distracters and react to distracter salience compared to younger? Further, since age is a known antecedent to CSE (Marakas, 1998), how much self-efficacy do older people compared to younger have with respect to computer use? Relatedly, how much experience do older people compared to younger have with respect to computer use? In this section we review the literature on cognitive aging, which refers to age-related changes in the allocation of mental resources (Park, 2000), to better understand how adult age relates to these concepts. In the process, we also review IS research that focuses on the concept of age.

2.4.1 THE INHIBITORY DEFICIT THEORY OF COGNITIVE AGING

Theories of selective attention explain how a subset of information can be effectively processed in the presence of distracting stimuli (Stoltzfus et al., 1993). The Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999) (also referred to as the Theory of Distraction Control; Darowki et al., 2008) is a major theoretical approach to cognitive aging (McDowd & Shaw, 2000; Smith, 1996) that focuses on the deliberate control of the contents of working memory.

Working memory is the memory responsible for managing the information required to perform cognitive tasks. It is a temporary storage and processing component in the human brain that keeps the information necessary to complete the task at hand active. In more applied terms, working memory holds a small amount of information that can be “worked on” by cognitive processes (Wickens et al., 2004). It is also referred to as “current consciousness” (Kausler, 1994, p. 149) or “short-term memory plus controlled attention” (Berti et al., 2004). Consider the example of dialing a telephone number after having looked it up. Once looked up, the number is held in working memory until it is completely dialed (Wickens et al., 2004). However, any distraction, for example someone counting aloud next to the person dialing, may result in slowed or incorrect dialing. Distractions have this impact on task performance since the capacity of working memory (i.e., the general capacity available for mental work) is very limited, at times to as little as one item (Dumas & Hartman, 2008). As individuals attend to distracting stimuli that call for processing, these distracters enter working memory and reduce the capacity available for current task processing. As a result, mental work on the task at hand becomes slowed and error-prone.

The inhibitory deficit view holds that older adults are differentially vulnerable to the presence of distraction (Darowki et al., 2008; Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999). Consistent with research on selective attention (Houghton & Tipper,

1994) the theory assumes an attentional inhibition mechanism that controls the negative impact distracting stimuli and thoughts may have on the processing of information related to the current task. Specifically, this mechanism directly inhibits or down-regulates the processing of distracting stimuli, regardless of whether such processing relates to stimuli in the task environment or to internal thoughts. In other words, distracting information is actively disattended (or disregarded). When an individual's inhibition functions effectively, distracting stimuli and thoughts do not enter working memory and hence do not interfere with the processing of current-task information. By contrast, reduced inhibitory effectiveness is associated with less suppression of response tendencies to distracting stimuli; hence, more distracters can enter working memory and can interfere with current task processing. As a result, attention cannot be sustained on the task at hand and task progress becomes slowed and error-prone. The theory indicates that the ability to suppress the processing of distracting stimuli and thoughts declines with age so that older people have less capacity for current task processing than younger when distractions appear (see Figure 2.10).

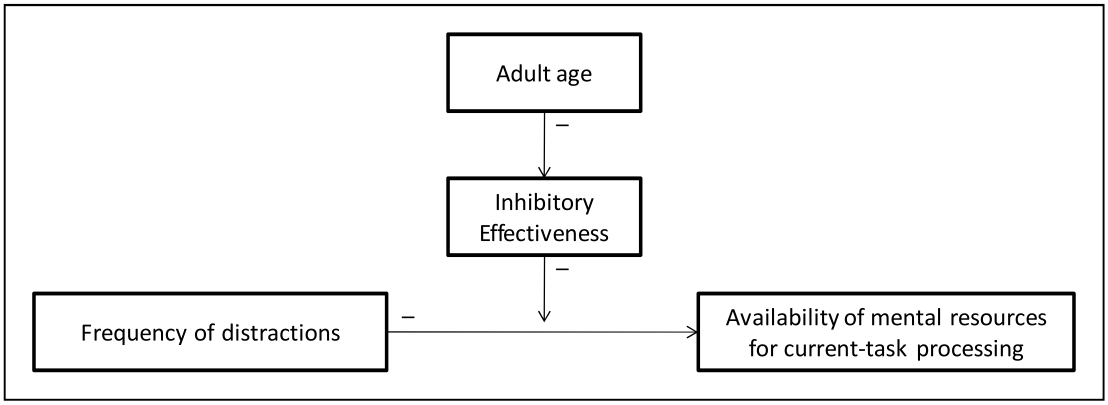

Figure 2.10 The Inhibitory Deficit Theory of Cognitive Aging

To illustrate, consider the everyday situations of reading the newspaper. The selection of one article involves ignoring other articles as well as photographs and advertisements that appear on the same page. Since their inhibitory mechanism is impaired, older individuals may face greater difficulty than younger people in sustaining attention on (i.e., allocating resources to) a target story to the exclusion of other available stimuli (Connelly et al., 1991).

The inhibitory system serves two major complementary functions, which are access of extraneous information to focal attention and deletion from attention (Hasher et al., 1999). The access function suppresses the processing of distracting information when the distraction first occurs. The deletion function serves to quickly remove attended-to but rejected information from attention. Since both these mechanisms are compromised in older adults, distracting information is more likely to gain access to focal attention and to continuously disrupt cognitive processing. In effect, older people are differentially “bothered” by distraction (Zacks & Hasher, 1997, p. 275).

The inhibitory deficit theory has received ample empirical support (e.g., Carlson et al., 1995; Connelly et al., 1991; Connelly & Hasher, 1993; Darowski et al., 2008; Hasher et al., 1999; Kane et al., 1994; Kim et al., 2007; May et al., 1999; Stoltzfus et al., 1993). Two early studies conducted by Hasher, Zacks, and colleagues were particularly influential (Zacks & Hasher, 1997). Connelly et al. (1991) conducted two experiments, one with 48 and another with 64 participants. In either experiment, half the subjects were younger (i.e., a mean age of approx. 19 years) and half were older (i.e., a mean age of approx. 69 years). In experiment one, analysis of variance revealed that both younger and older adults' task performance was reduced by the presence of distracters, and that older people were undoubtedly more affected. In experiment two, the same analytical technique showed that the costs of distraction in terms of performance reductions on the current task were particularly large for older people when the distracter had a meaningful association with the current task. In summary, the study evidenced that older people are more susceptible to distraction than younger adults, especially in the case of meaningful distracting stimuli.

In building on the Connelly et al. paper, another study by Hasher, Zacks, and colleagues (Carlson et al., 1995) showed that when distracters appear in predictable locations, older peoples' inhibition improves markedly and becomes almost as effective as younger adults' inhibition. Further, predictable locations offset the relatedness effect found by Connelly et al., implying that older individuals are not particularly vulnerable to distractions that bear a meaningful relation to the current task when the distracters appear in fixed locations. These results were obtained through analysis of variance on data from three experiments, two with 64 and another with 32 participants. In all experiments, half the subjects were younger (i.e., a range of approx. 17-24 years) and half were older (i.e., a range of approx. 62-75 years). The authors replicated and extended the findings from prior studies, thereby indicating that older people are more vulnerable to distracting stimuli than younger adults.

2.4.2 ATTENTIONAL AMPLIFICATION AND AGING

Recent research investigating the relationship between attentional capture and aging has indicated that “older adults tend to be more affected by salient events such as flashing, high-intensity lights as well as stimuli that appear to pose an immediate threat” (Fisk et al., 2009, p. 22). Hence, object salience may affect older people differentially. Consistent with this notion, some empirical studies indicate that age-related differences in attentional capture may exist.

A comprehensive literature search across more than 40 databases including four Psychology databases revealed two empirical studies indicating that older people may be more susceptible to attentional capture. Pratt and Bellomo (1999) conducted two experiments with 16 younger and 16 older participants. The younger subjects ranged in age from 18 to 26 years, the older from 62 to 82 years. Analysis of variance showed age-related differences in attentional capture across both experiments, at least when older individuals’ attention was set for appearing targets. Similarly, Whiting et al. (2007) found that older people compared to younger individuals experience larger attentional capture effects. The authors conducted an experiment with twenty-four younger and twenty-four older individuals. The younger participants ranged in age from 19 to 23 years, the older from 60 to 80 years. Analysis of variance revealed age-related differences in attentional capture when only stimulus-driven information was available.

However, there is substantial conflict in the literature. The visual search/attention literature documents that introducing new motion to a previously existing (i.e., old) object captures attention equally well for younger and older adults (Christ et al., 2008). Similarly, Kramer et al. (1999) found age-equivalence of attentional capture for new objects that appear in the visual field. To complicate matters further, one study (Pratt & Bellomo, 1999) found that older individuals compared to younger adults exhibit larger capture effects for new objects but not for color distracters, at least when capture effects are measured by response time. Hence, some aspects of salience may show age differences, while others do not. Yet, another study (Colcombe et al., 2003) observed age-equivalence for both color and new object distracters. Accordingly, the literature is unclear as regards age differences in attentional capture.

2.4.3 COMPUTER EXPERIENCE, COMPUTER SELF-EFFICACY, AND AGING

Some researchers argue that since older people have less working memory capacity than younger, any such aspect as experience, which enhances the amount of working memory available for the current task, should benefit them more (e.g., Van Gerven et al., 2000). Tomporowski (2003) examined this proposition empirically by applying cognitive load theory, which indicates that such conditions that overload working memory capacity can lead to performance declines. While he found that practice reduces both younger and older individuals' ratings of perceived mental workload, he failed to detect age differences. Other empirical evidence on age effects in the domain of experience is lacking. However, in the context of ICTs, it is well known that older people have less experience with computers than younger people (e.g., Fisk et al. 2009; Mead et al., 2000; Rogers et al., 1996; Rousseau et al., 1998; Sharit & Czaja, 1999). In fact, many older adults have very limited or even no computer experience (Czaja & Sharit, 1998).

To illustrate, Czaja and Sharit (1998), using chi-square difference tests, found a highly significant difference in computer experience across age groups. More specifically, 54% of their older subjects, compared to 17% of their younger participants, had no prior experience with computers. In total, 110 individuals participated in Czaja and Sharit's experiment, in which older subjects were defined as those between 60 and 75 years of age, and younger subjects were defined as those between 20 and 39 years. This finding supports the idea that older adults have less experience with computers and may, therefore, require more mental resources to accomplish computer-based tasks[4], potentially resulting in more stress and lower task performance.

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[4] This conclusion is unlikely to be an artifact of our time; good reasons exist to believe that differences in computer experience between younger and older people will continue to exist in the future. In Section 3.4.3 we advance specific arguments for this belief on the bases of continuing educational differences between younger and older people and differences in the ease of ICT use, two major drivers of computer experience.

Additionally, consistent with Benbasat & Zmud's (1999) argument that the nature of ICTs continuously evolves and changes at a rapid rate, we suggest here that technology will continue to evolve at a pace at least as high as the one observed over the last decades. More specifically, consistent with Moore's law (established in 1958), the speed and complexity of computers has risen exponentially over the last decades since transistors in integrated circuits have continuously become smaller in size. More importantly, the pace of this development has become faster – not slower – over time (Pacholski, 2006). While at the beginning of the 20th century the speed of computer calculations doubled every three years, this process was shortened to two years in the middle of that century. Today, this process takes only eighteen months (Pacholski, 2006). Thus, the pace of the computer evolution has become faster over the last century, not slower, and there is little evidence suggesting that this trend will change. In fact, since technological advances have become so regular, many observers expect them to continue "indefinitely" (Borsuk & Coffey, 2003). However, some argue that this trend cannot continue indefinitely since transistors can only become so small in size and would reach atomic dimensions already by 2050 (Borsuk & Coffey, 2003). Still, this may not reduce the pace of the computing evolution since new developments are on the horizon that may outperform regular transistors. For example, silicon processors have recently been joined in laboratory settings with neural cells so that information can flow directly from biological tissue to the silicon (Pacholski, 2006). As another example, IPv6, which replaces IPv4, supports four times as many bits for an internet protocol address, vastly expanding the number of devices and users on the internet. Hence, there is reason to believe that technology will continue to evolve at a pace at least as high as the one observed over the last decades, if not higher.

Similar to computer experience, computer self-efficacy (CSE) may be limited in older adults since “in cultures that revere youth and negatively stereotype the elderly, age becomes a salient dimension for self-evaluation” (Bandura, 1986, p. 418). Further, normal age-related changes in cognitive abilities threaten older individuals' beliefs in their ability to deal with the variety of cognitive demands involved in computer work (Reed et al., 2005). Consistent with this notion, recent studies predicted and found that older adults have lower CSE than younger people. For example, Marakas et al. (1998) indicated that age is an important and known antecedent to CSE, such that older compared to younger individuals have lower self-efficacy with regard to computer use. Likewise, Laguna and Babcock (2000) reported that older adults have lower CSE than younger individuals. In a sample of 144 individuals ranging in age from 18 to 86 years, they found overwhelming evidence for a relationship between age and CSE. The relationship between the two concepts was strongly negative with a correlation coefficient of almost -0.50. Another study (Czaja et al., 2006) came to similar conclusions. Czaja et al.’s sample consisted of 1,204 adults ranging in age from 18 to 91 years with a mean age of 47 years. Like Laguna and Babcock before them, they found overwhelming support for a negative relationship between age and CSE.

2.4.4 IS RESEARCH ON THE CONCEPT OF AGE

Recent research (Venkatesh et al., 2003, p. 469) indicates that age is a “key demographic variable” for IS research. Age has predominantly been studied to explain for whom certain user perceptions result in individual adoption and sustained use of technology in the workplace. For example, Venkatesh et al. (2003) included age as a moderator in their Unified Theory of Acceptance and Use of Technology. They showed that age moderates the links between performance expectancy, effort expectancy, social influence, and facilitating conditions as independent variables, and intention to use a technology as the dependent variable. More specifically, age negatively moderated the link between performance expectancy and intention to use, while it positively moderated the other links.

While IS research has included the concept of age in studies on technology acceptance, few studies have actually focused their attention on age. A comprehensive search across over 40 databases using such keywords as “age,” “old,” and “older” revealed only three IS studies that deliberately focused their attention on the concept of age. Morris and Venkatesh (2000) examined age differences in technology adoption decisions to help businesses deal with the aging workforce. Using the theory of planned behavior, they developed a model that integrates age with attitude toward a technology, subjective norm, perceived behavioral control, and system use. Morris and Venkatesh (2000) found that adoption decisions were indeed influenced by age, such that older workers were more influenced by subjective norm and perceived behavioral control than younger people, but less by their attitude toward the technology. With their sole reliance on the theory of planned behavior to derive their model, the authors chose not to use a theory of aging to predict age differences and interpret their findings.

Similarly, Morris et al. (2005) looked at three-way interactions between age, gender, and the constructs provided by the theory of planned behavior to predict employee decisions about the adoption of new technology. They found that gender differences in technology perceptions were significant among older workers, while such differences were not found among younger workers. The authors concluded that common stereotypes describing technology as a male-oriented area are fading away—particularly among younger workers. Like Morris and Venkatesh before them, the authors' solely relied on the theory of planned behavior to derive their model. Since the theory of planned behavior does not address age-related differences at all, Morris et al.'s study was largely atheoretical with regard to age-related differences in technology adoption.

Another study (Lam & Lee, 2006) examined internet adoption by older individuals. Using social cognitive theory, the authors explored the effects of internet self-efficacy and outcome expectations on older peoples' extent of internet usage. In a sample of almost 1,000 individuals aged 55 and older, they found general support for their model. Both internet self-efficacy and outcome expectations were significant predictors of usage intention for older adults. Since the authors solely relied on social cognitive theory, which makes some assumptions about age, but is not a theory of aging, the study was largely atheoretical with regard to technology adoption by older adults.

To summarize, IS studies that have focused on age and age-related differences have derived their models and interpreted their findings without reliance on theories of aging. As such, IS scholarship is largely atheoretical with regard to its treatment of age. Further, IS research with an age focus is restricted to the domain of technology adoption, be it in the context of general technology adoption or internet usage. Other domains, such as technostress, have yet to be infiltrated. Not surprisingly, recent IS research (Tarafdar et al., 2007) called for an examination of the role of age in technostress. In conclusion, aged-focused IS research needs to be more theoretical with regard to its treatment of the concept of age, and more diversified in terms of the phenomena under investigation (see Table 2.5).

Source	Phenomenon under Examination	Theories used	Bearing Theories used have on the Concept of Aging	Atheoretical with regard to the Concept of Aging
Morris & Venkatesh (2000)	Technology Adoption	Sole reliance on the Theory of Planned Behavior	None, the Theory of Planned Behavior is not concernced with age-related differences	✓
Morris et al. (2005)	Technology Adoption	Sole reliance on the Theory of Planned Behavior	None, the Theory of Planned Behavior is not concernced with age-related differences	✓
Lam & Lee (2006)	Technology Adoption	Sole reliance on Social Cognitive Theory	Little, Social Cognitive Theory makes some assumptions about age, but is not a theory of aging	✓

Table 2.5 IS Research with a Focus on the Concept of Age

2.4.5 SECTION SUMMARY

Our review of the literature on aging yields interesting insights for age-related manifestations in a model of technostress. Consistent with the literature on selective attention, the Inhibitory Deficit Theory of Cognitive Aging postulates an attentional inhibition mechanism. This mechanism enables people to control attention and sustain the focus of attention on a particular active task despite the presence of distracting stimuli (Hasher & Zacks, 1988; Zacks & Hasher, 1997). The theory holds that attentional inhibition is impaired in older adults, thereby enabling more distractions to gain access to mental resources. This means that older compared to younger adults experience greater interference of distractions with current task processing, implying that fewer cognitive resources are available for processing task-related information. As a result, older people have more trouble sustaining their attention on the current task than younger adults and experience slower and more error-prone task progress.

The literature on attentional amplification is inconclusive and ambiguous as to whether older people may be differentially affected by stimulus-driven attentional capture (e.g., Christ et al., 2008; Pratt & Bellomo, 1999). Neither theoretical arguments nor empirical findings are consistent. Instead, age effects in the realm of stimulus-driven attentional capture appear to depend heavily on a variety of factors including the specific tasks applied, measures taken, and stimuli examined. However, more recently, some major reviews suggested that older people may indeed be more susceptible to stimulus-driven attentional capture than younger adults (e.g., Fisk et al., 2009), particularly for salience in terms of color code, dynamism, and auditory alerts.

Regarding differential effects of computer experience for older compared to younger people, our review finds very limited evidence. While some researchers (e.g., Van Gerven et al., 2000) argue on the basis of older peoples’ lower working memory capacity that experience should benefit them more, the empirical evidence does not support this claim. However, the literature consistently indicates that older individuals have less experience with computers than younger people (e.g., Czaja & Sharit, 1998; Fisk et al. 2009; Sharit & Czaja, 1999).

As regards age-related differences pertaining to computer self-efficacy, recent research suggests that age-related changes in cognitive abilities threaten older individuals' beliefs in their ability to deal with the variety of cognitive demands involved in computer work (Reed et al., 2005). Consistent with this idea, several recent studies report that older adults have lower computer self-efficacy than younger people (e.g., Czaja et al., 2006; Laguna & Babcock, 2000).

Finally, our review of age-focused IS research points to a gap in the literature. Although IS research largely recognizes the importance of studying the aging workforce (Morris et al., 2005; Venkatesh et al., 2003), very few IS studies have focused on examining adult age. Further, age-focused IS studies have been atheoretical with respect to their treatment of age, and have been very single-sided; all age-focused IS research has examined the role of age in technology adoption decisions. Hence, IS research needs to be more theoretical with respect to its treatment of age and more diversified in terms of the phenomena under investigation.

Figure 2.11 illustrates how our review of the literature on aging adds to our model of technostress by elucidating potential age-related manifestations. The inhibitory deficit view holds that older adults’ inhibitory mechanism is less effective than younger peoples’ mechanism, thereby enabling more T-M interruptions to give rise to perceptions of mental workload in computer-based tasks. Further, older individuals may be more susceptible to high levels of salience of T-M interruptions, implying that interruptions combining an intrusive color with dynamism and sound may be more likely to give rise to perceptions of mental workload in older compared to younger people. Similarly, because older compared to younger people have significantly lower levels of computer experience and computer self-efficacy, they may benefit to a lesser extent from these concepts' potential to mitigate the negative consequences of T-M interruptions. The next chapter summarizes our entire literature review with the purposes of outlining the key takeaways for developing our research model and pointing to gaps in the extant literature that need to be bridged.

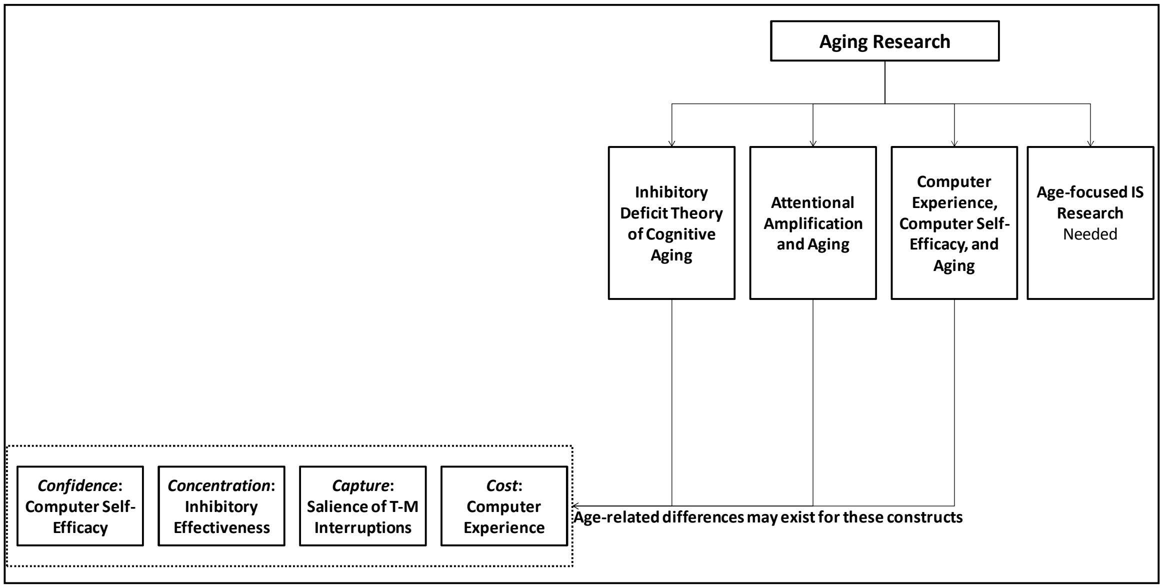

Figure 2.11 Illustration of how our review of the aging literature informs model development

2.5 CHAPTER SUMMARY

This chapter reviewed the literature pertaining to individual stress and task performance, selective attention, and cognitive aging. Table 2.6 highlights the key takeaways from the contributing literature that inform model development.

Key Takeaway	Elaboration	References
Stress formation is a *transactional process* .	Contemporary stress research considers stress formation a transactional process, meaning that stress arises not from a stimulus per se, but from the interaction between a person and the environment.	(Cooper et al., 2001; Hancock & Szalma, 2008; Lazarus, 1999; Ragu-Nathan et al., 2008; Tarafdar et al., 2007)
The *person-environment fit perspective* is best to examine age-related differences in technostress	The person-environment fit perspective provides a framework for understanding how stress emerges from the interaction between a person and a stressor. As such, it is well-suited to address such individual differences as age in a model of stress. Further, this model incorporates the concepts of coping (e.g., through self-efficacy) and task performance.	(Bandura, 1982; Caplan, 1987; Edwards, 1996; Folkman & Lazarus, 1984; Lazarus, 1966, 1999; Ozer & Bandura, 1990; Pervin, 1968)
The *frequency of technology-mediated interruptions* impacts person-environment fit.	Technology-mediated interruptions indirectly affect stress through their impact on person-environment fit.	(Pervin, 1968; Warburton, 1979)
	The frequency of incoming distractions or interruptions reduces person-environment fit.	(Hasher & Zacks, 1988; Lazarus, 1999; Folkman & Lazarus, 1984; Zacks &
Perceived *mental workload* is the stressor that ultimately creates stress.	Perceived mental workload refers to the perceived ratio of the mental resources required to perform the current task to the resources available. Attentional capacity is a major such resource. Mental workload perceptions constitute a stressor of particular importance in the form of person-environment misfit.	(Endsley, 1995; Hart & Staveland, 1988; Wickens et al., 2004)
Computer self-efficacy may yield interesting insights regarding age-related differences in technostress	Age is an important and know antecedent to computer self-efficacy, which may serve as a coping mechanism in a theory of technostress. As such, computer self-efficacy may yield interesting insights into age-related differences in the technostress phenomenon.	(Czaja et al., 2006; Lazarus, 1999; Marakas et al., 1998; Ragu-Nathan et al. 2008)
Selective attention is an individual's ability to selectively process some information sources and ignore others.	Since people cannot process all the stimuli that continuously bombard their senses, selective attention is necessary to ensure that the most relevant information is processed and less relevant information is excluded from receiving processing resources.	(Rogers & Fisk, 2001; Strayer & Drews, 2007; Houghton & Tipper, 1994)
Attentional inhibition improves selective attention efficiency.	Attentional inhibition enables people to deliberately suppress distracting information, thereby effectively reducing the quantity of distractions or interruptions that gain access to mental resources.	(Houghton & Tipper, 1994; Hasher & Zacks, 1988; Zacks & Hasher, 1997; Darowski et al., 2008)

Table 2.6 Key Takeaways for Model Development

Key Takeaway	**Elaboration**	**References**
Attentional amplification of salient distractions reduces selective attention efficiency.	Individuals are more likely to attend to stimuli that are amplified. Hence, distracting stimuli that are amplified through such mechanisms as flashing or stimuli that present a threat are more likely to gain access to mental resources.	(Strayer & Drews, 2007; Tipper & Houghton, 1994; Wickens et al., 2004)
Experience reduces the attentional requirements of a task.	Experience gradually replaces resource-intense effortful information processing for performaning a task by more efficient automatic processing. Thus, experience reduces the cognitive burden associated with performing a task and frees mental resources.	(Lee et al., 2007; Liu et al., 2004; Rogers & Fisk, 2001; Sweller, 1988, 1994)
Cognitive aging refers to age-related changes in mental resources.	As individuals grow older, the availability of mental resources used to perform mental tasks becomes subject to change. Generally, older adults have fewer resources available.	(Park, 2000)
Older compared to younger peoples' *inhibitory mechanism is impaired,* resulting in lower task performance.	The Inhibitory Deficit Theory of Selective Attention suggests that - compared to younger individuals - older peoples' inhibitory mechanism is less effective, thereby enabling more distracting stimuli to gain access to mental resources and interfere with current task processing. As a result, a single train of thought cannot be maintained, and progress on the current task becomes slowed and error-prone.	(Darowski et al., 2008; Hasher & Zacks, 1999; Hasher et al., 1991; Zacks & Hasher, 1997)
Older compared to younger peoples' *amplification mechanism is more effective,* resulting in lower task performance.	Compared to younger individuals, older people are more likely to attend to salient stimuli, thereby enabling more distracting information to gain access to mental resources and interfere with current task processing. As a result, a single line of thought cannot be maintained, and progress on the current taks becomes slowed and error-prone.	(Fisk et al., 2009; Lorenzo-Lopez et al., 2008; Pratt & Bellomo, 1999; Whiting et al., 2007)
Older compared to younger people have *lower levels of computer experience* .	As a result of their lower computer experience, older compared to younger adults may need more cognitive resources to operate the computer, e.g. to move the mouse across the screen. Hence, they may have fewer resources to spare for T-M interruptions.	(Panek 1997; Sharit & Czaja, 1999)
Older compared to younger people have *lower levels of computer self-efficacy* .	As a result of their lower computer self-efficacy, older people may feel more threatened in stressful situations that involve a computer.	(Czaja et al., 2006; Marakas et al., 1998)

Table 2.6 (continued) Key Takeaways for Model Development

Our review finds that stress arises from the interaction between a person and the environment rather than from a stimulus per se (Hancock & Szalma, 2008; Lazarus, 1999). Consistent with this understanding, the person-environment fit perspective (Pervin, 1968; French et al., 1982) constitutes the most appropriate theoretical perspective for studying such individual differences as age in a model of technostress. The essence of P-E Fit is captured by the construct ‘perceived mental workload’ (Kaldenberg & Becker, 1992), which increases in correspondence with cognitive demands and is the stressor that ultimately generates stress. We also find that T-M interruptions may affect stress indirectly through their impact on person-environment fit and that it is the frequency of incoming interruptions that directly impacts such fit (since the P-E Fit perspective, consistent with the inhibitory deficit theory, conceptualizes task demands in terms of environmental demands per unit time, Warburton, 1979). Further, computer-self efficacy is an underexplored construct in the technostress literature that may yield interesting insights into age-related differences. More specifically, the construct relates to the phenomenon of coping and is a direct causal consequence of age.

The selective attention literature indicates that attentional inhibition and distracter salience serve to reduce and increase vulnerability to distraction, respectively (Houghton & Tipper, 1994). In so doing, these mechanisms influence the effect of interruptions on P-E Fit in opposite directions. Our review further finds that experience can reduce the mental resource requirements of a task (Rogers & Fisk, 2001), and that – in the context of technostress – computer experience is negatively related to computer anxiety (Beckers & Schmidt, 2003).

Research on cognitive aging indicates that attentional inhibition is weaker in older adults, implying that older individuals are more vulnerable to distractions than younger people (Hasher & Zacks, 1988; Zacks & Hasher, 1997). As a result, older adults have fewer mental resources available for performing the current task than younger individuals when distractions appear. Regarding attentional amplification, the literature shows substantial ambiguity as to whether age differences exist (e.g., Christ et al., 2008; Pratt & Bellomo, 1999). Our review further shows that older people possess lower levels of computer experience (e.g., Czaja & Sharit, 1998; Fisk et al. 2009) and computer self-efficacy (e.g., Czaja et al., 2006; Marakas et al., 1998). Moreover, we find that–although IS research recognizes the importance of studying age-related differences in technology use–age-focused IS research is largely atheoretical and single-sided with respect to the concept of age. Hence, we point to a gap in the literature as regards the theory-based examination of age-related differences in technostress.

As illustrated in Figure 2.12, prior literature has primarily focused on examining technostress, aging, and selective attention in isolation. Some studies have looked at the intersection of two such areas. For example, Hasher and Zacks (1988) investigated the connection between selective attention and aging, and Ragu-Nathan et al. (2008) looked at the intersection between technostress and aging. However, no research to date has examined the point at which all three research areas intersect, although this point yields the greatest potential for explaining age-related differences in technostress.

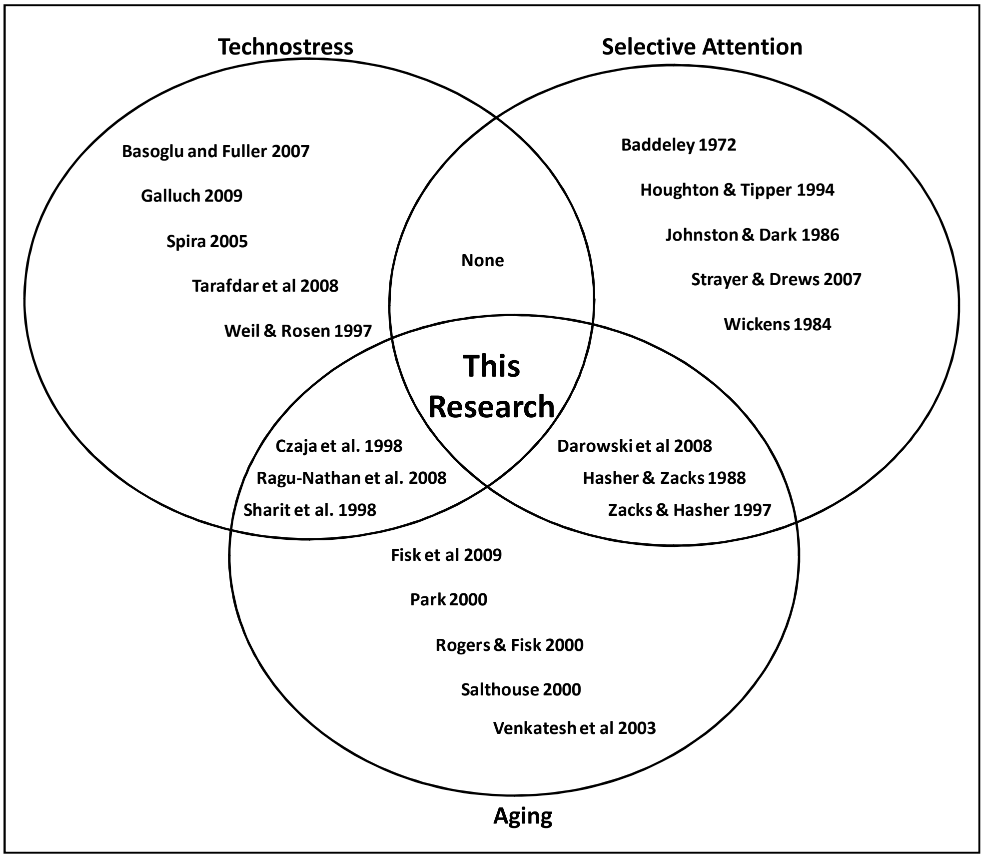

Figure 2.12 Illustrative Studies in the Contexts of Technostress, Selective Attention, and Aging

Furthermore, we find that research examining the role of age in technostress is largely inconclusive and nascent. Similarly, precious little work has examined the roles of T-M interruptions, computer experience, and computer self-efficacy in the context of technostress. Not surprisingly, recent research has called for such investigations.

Figure 2.13 illustrates how our literature review frames a model of T-M interruptions, ageing, stress, and task performance. It shows that stress research provides the core model connecting ICTs, stress, and task performance, and that age and computer self-efficacy are important constructs to examine within the context of such technological stressors as T-M interruptions. More specifically, the P-E Fit perspective combined with the literature on T-M interruptions indicates that the frequency with which T-M interruptions appear increases perceptions of person-environment misfit in the form of mental workload (the P-E Fit perspective conceptualizes resource demands in terms of environmental demands per unit time or frequency). Perceived mental workload, in turn, gives rise to the experience of stress, which subsequently diminishes performance on computer-based tasks. Further, since age is an important antecedent to CSE, CSE may yield interesting insights regarding age-differences in the context of technostress.

Selective attention theory provides additional constructs that can further explain the link connecting ICTs to individual stress and performance on computer-based tasks. These constructs include the inhibitory effectiveness of individuals, the salience of T-M interruptions, and computer experience. While the inhibitory mechanism may enable people to actively disregard appearing T-M interruptions, thereby reducing the number of such interruptions that can increase perceptions of mental workload, the salience of T-M interruptions may have the opposite effect. As T-M interruptions become relatively salient by appearing in an intrusive color with dynamism and sound effects, they may become more likely to capture individuals' attention and give rise to perceptions of mental workload. Further, under the condition of high levels of computer experience, T-M interruptions can potentially draw mental resources away from computer-based tasks without increasing perceptions of mental workload. However, older people may benefit less than younger individuals from these mechanisms' moderating impacts on technostress.

The literature on cognitive aging suggests that the inhibitory effectiveness of individuals, the salience of T-M interruptions, the level of computer experience, and the level of computer self-efficacy may substantially vary with age, thereby affecting older compared to younger people differently. More specifically, the Inhibitory Deficit Theory of Cognitive Aging, the literature on stimulus-driven attentional capture, and the literature on experience indicate that T-M interruptions may be more likely to give rise to perceptions of mental workload in older compared to younger adults. Further, since age is an important antecedent to CSE such that older adults have significantly lower levels of CSE than younger individuals, older people may benefit less from CSE's potential to mitigate the consequences of T-M interruptions on individual stress.

These four points through which age may impact technostress tie into the 4 C's introduced earlier. The Inhibitory Deficit Theory of Cognitive Aging, which is entirely consistent with the literature on selective attention, leads us to coin the term Concentration, which implies that older compared to younger adults may experience more trouble concentrating on the task at hand when T-M interruptions appear. Similarly, the literature on stimulus-driven attentional capture suggests that older individuals may be more susceptible to high levels of salience of these interruptions, an aspect of age that we refer to as Capture. Further, as indicated by the literature on the attentional implications of experience along with research on computer experience, older adults may incur higher resource-related Costs from attending to T-M interruptions. Finally, as suggested by Self-Efficacy Theory and research on CSE, older adults may be less likely to cope effectively with the additional mental workload arising from T-M interruptions, an aspect of age that we refer to as Confidence.

In the next chapter, we integrate all these facets of individuals' interactions with ICTs into a single articulated model of technostress that lies at the intersection of technostress, aging, and selective attention.

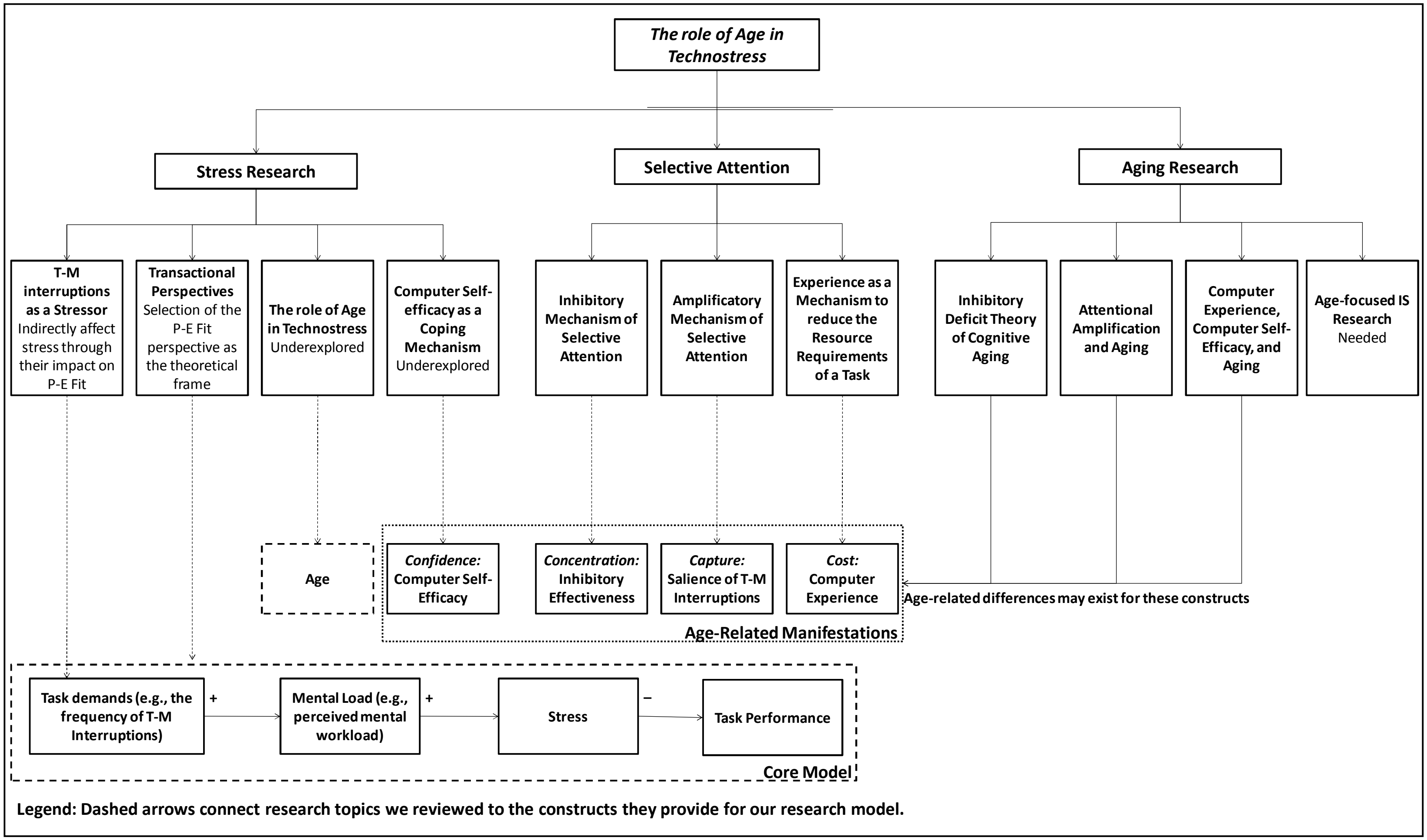

Figure 2.13 Illustration of how our literature review informs model development.

Chapter Three: Research Model

3.1 INTRODUCTION

Using the theories and constructs provided by the extant literature, we now turn to developing an integrative model of ICTs, aging, individual stress, and task performance. With the purpose of integrating all these aspects into a single unifying theme, we begin by discussing our research model at an abstract level. This discussion proceeds in two steps. The first step involves the development of a core model of technostress, which conceptualizes the causal chain between T-M interruptions, stress, and task performance. The second step involves adding to this core by elucidating major concepts through which age impacts technostress. We conclude this abstract discussion with a visual representation of the full research model. Following this, we develop concrete hypotheses that formalize and elaborate upon the proposed relationships.

3.2 CORE RESEARCH MODEL

Grounded in the P-E Fit perspective (Pervin, 1968), the following model explains the causal chain connecting T-M interruptions to individual stress and task performance (see Figure 3.1 and Table 3.1). We propose that as T-M interruptions appear with increasing frequency, which is the general conceptualization of environmental demands in the P-E Fit perspective (Warburton, 1979), they draw more working memory capacity away from the current task, resulting in a perceived misfit between mental resource supply and demand. Accordingly, we model T-M interruptions as leading to perceptions of P-E misfit in the form of mental workload. We further propose on the basis of the P-E

Fit perspective that perceptions of mental workload, which are closely associated with the threat of low performance and thus constitute a particularly important stressor (Endsley, 1995), result in stress for individuals. This link between perceived mental workload and individual stress may be especially pronounced for computer-based tasks, which place particularly high mental demands on individuals (Birdi & Zapf, 1997). Ultimately, this technostress reduces individual performance on computer-based tasks.[5]

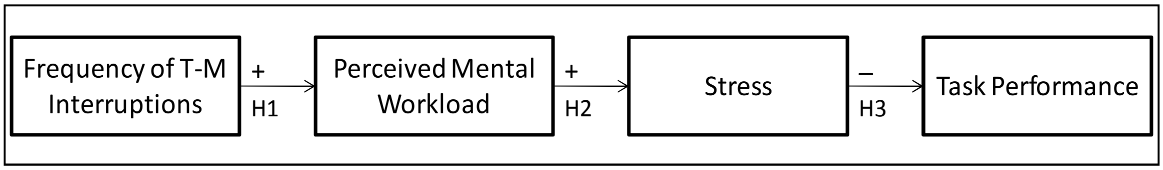

Figure 3.1 Core Research Model

Construct	Defintion
Frequency of T-M interruptions	Number of technology-mediated (T-M) distractions in a given time interval that shift individuals' attention away from a current task and require conscious effort to return to the original task (Damrad-Frye & Laird, 1989; Galluch; 2009).
Perceived mental workload	Perceived ratio of mental resources required to accomplish a task to mental resources available. Working memory capacity is a major such resource. Such distractions as T-M interruptions reduce the mental resources available for the current task, thereby increasing perceptions of mental workload (Hart & Staveland, 1988; Wickens et al., 2004).
Stress	Extent to which an individual responds psychologically or physiologically to a perceived misfit between resource availability for current task performance and environmental resource demand (Caplan et al., 1975; Lazarus, 1966; 1999).
Task performance	Extent to which an individual's task output is effective in meeting task objectives (Burton-Jones & Straub, 2006).

Table 3.1 Construct Definitions for Core Model

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[5] While the P-E Fit perspective is silent on the issue of whether a direct effect of perceived mental workload on task performance can be expected, such an effect appears intuitively reasonable. People may invest full resources when they face work overload, implying that further increases in task demands may directly result in performance decrements (Yeh & Wickens, 1988). In other words, when people hit their working memory capacity limit, any increase in mental workload perceptions beyond their limit may directly reduce performance. However, the literature is mixed as to whether stressors have both direct and indirect effects on performance. While some (e.g., Lusch & Jaworski, 1991) report that stressors have indirect effects only, others (e.g., Netemeyer et al., 2005) suggest that stressors may have both direct and indirect effects on performance. The results of our experiment supported the former notion; mental workload had no direct effect on task performance ($b = -0.025$, Std. Error = 0.092, $p > 0.05$).

To illustrate, consider the example of Skype® Voice over IP (VoIP). With Skype activated, an individual working on a computer-based task can unexpectedly receive phone calls via VoIP. In the current Skype version (i.e., 4.2.0.169), an incoming VoIP call appears as a new object in the center of the computer display. As a result of this T-M interruption, mental resources are drawn away from the task when the person attends to the object (for example, the person may be thinking about whether to take the call). More specifically, upon entering working memory, the information related to the VoIP object reduces the amount of mental resources available for the main task, while the VoIP object does not affect the resource demands of the main task. The resource demands remain unaffected since the interruption does not change the nature of the task, its objectives, or timeline. 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 T-M interruptions. Yet, while the task demands remain unaffected, the resources available to the accountant are reduced when attending to interruptions. As a result of this imbalance introduced by T-M interruptions, perceived mental workload increases. Importantly, mental workload will increase more for a greater number of incoming VoIP calls per unit time (i.e., a greater frequency) (Warburton, 1979). Since mental workload is closely associated with the threat of low performance on computer-based tasks, it gives rise to technostress. Ultimately, the stress arising from this T-M interruption reduces individual performance on computer-based tasks.

Since our core model is grounded in the P-E Fit perspective, which fully recognizes such individual differences as adult age (Blau, 1981; Lazarus, 1999; Park, 2000; Warburton, 1979), it serves as a baseline model that lays the ground for developing age-related manifestations in the context of technostress. As shown in our literature review, age can impact different links in the causal sequence from the external event to the consequences of stress (Kahn & Byosiere, 1992). It can moderate the link between the frequency of T-M interruptions and perceptions of mental workload as well as the link between these perceptions and subsequent experiences of stress. However, the positioning of age-related manifestations along these linkages will have to be aligned with the different facets of cognition underlying them.

The first link between the frequency of T-M interruptions and perceptions of mental workload is concerned with one particular facet of cognition: mental resources (Basoglu & Fuller, 2007; Wickens, 2004; Warburton, 1979). More specifically, it concerns the task demands for and the availability of mental resources. Accordingly, such concepts as inhibitory effectiveness, interruption salience, and computer experience, through which age may impact technostress, are pertinent to this link. While inhibitory effectiveness and interruption salience directly speak to the availability of mental resources, computer experience speaks to the amount of mental resources required for the performance of computer-based tasks, such that people with more experience may require relatively fewer mental resources to perform the task. With its focus on resource amounts, this link does not address such other aspects of cognition as thinking processes and beliefs, which, in a model of stress, pertain to feelings of threat generated by such stressors as high levels of workload (Bandura, 1989).

The second link between mental workload perceptions and subsequent experiences of stress is concerned with thinking processes and how people interpret information (Lazarus, 1999). This link relates to the general idea that positive thinking can help a person deal with a stressful event by positively coloring the event’s cognitive interpretation, so that the extent to which this event manifests itself in stress is lessened. Accordingly, such beliefs as CSE, which are positive in nature and, thus, enable positive thinking, are pertinent to this link (Bandura, 1989; Lazarus, 1999).

By contrast, such beliefs as CSE are less relevant to the first link between the frequency of T-M interruptions and mental workload perceptions since – while pertinent to cognition in the form of thinking processes – beliefs have less relevance for the amount of cognitive resources required for task performance or those available. Beliefs can alter the interpretation of events by impacting thoughts (Bandura, 1989; Lazarus, 1999), but not the extent to which such external events as interruptions impact the balance of mental resources. More specifically, in contrast to inhibitory effectiveness, interruptions salience, and computer experience, CSE 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).

By the same token, although it may intuitively seem plausible that such other concepts as computer experience may affect thinking processes and may, hence, relate to the second link between mental workload perceptions and subsequent experiences of stress, the literature does not support this notion. Rather, since computer experience is not a belief, which would be able to modify the interpretation of events by impacting thoughts (Bandura, 1989; Lazarus, 1999), but a simple state of affairs (Harrison & Rainer, 1992), it is unlikely to affect what people think and how they interpret stressors. In line with these considerations, the positioning of age-related manifestations along the linkages in our baseline model will have to be aligned with the different aspects of cognition underlying these linkages.

3.3 AGE-RELATED MANIFESTATIONS

To develop pertinent age-related manifestations of differences in individual stress responses to T-M interruptions, we now turn to elucidating major concepts through which age impacts our baseline model. Grounded in prior research and consistent with the P-E Fit perspective, we propose that inhibitory effectiveness, computer experience, and computer self-efficacy (CSE), all of which are user-centric concepts (i.e., these concepts vary across technology users), and the salience of T-M interruptions, a technology-centric concept, connect adult age to the technostress phenomenon. We refer to the age-related manifestations on inhibitory effectiveness, computer experience, CSE, and the salience of T-M interruptions, as the 4 C's: Concentration, Cost, Confidence, and Capture, respectively.

Concentration means that, due less effective inhibition, older people face more trouble concentrating on the current task than younger adults when T-M interruptions appear. More specifically, inhibitory effectiveness, which relates to the idea that people can actively and purposefully ignore distracting stimuli (Hasher & Zacks, 1988;

Houghton & Tipper, 1994), may be lower in older than younger individuals, thereby potentially leading older individuals to experience higher levels of P-E misfit in the form of mental workload.

The Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988), which is an important theoretical approach to aging (McDowd & Shaw, 2000; Smith, 1996), postulates an attentional inhibition mechanism that enables individuals to control the extent to which they attend to distractions. This mechanism has also been termed distraction control (Darowski et al., 2008). Because of controlled attention, people can concentrate their mental resources on a particular active task, such as a computer-based one, despite the presence of such distracting stimuli as T-M interruptions. As a result, the interference of T-M interruptions with current task processing is minimized, and the focus of mental resources on the computer-based task at hand is maximized. However, based on the finding that older compared to younger people have substantially more distracting information stored in their working memory, the theory holds that attentional inhibition is compromised in older adults. Consequently, more such distracting stimuli as T-M interruptions may gain access to mental resources in older adults, breaking the concentration on the current task. As a result, older people may have fewer mental resources available to meet task demands than younger individuals when T-M interruptions appear, leading to higher perceptions of mental workload.

To illustrate the logic behind Concentration as an age-related manifestation of differences in individual stress responses to T-M interruptions, let us revisit the example of Skype VoIP. Individuals high in inhibitory effectiveness can actively ignore the new object associated with the VoIP call and remain concentrating on the task at hand. As a result, these individuals are unlikely to lose mental resources to T-M interruptions in the form of, for example, VoIP calls, implying that their mental resources available to meet task demands are not affected by the technology. However, since older individuals face greater difficulty disregarding such distracting stimuli as T-M interruptions, they may devote more mental resources to the VoIP call, for example, thinking about whether to take the call. In consequence, they may have fewer mental resources available to meet the demands of computer-based tasks and, thus, perceive higher levels of P-E misfit in the form of mental workload.

Similar to Concentration as an age-related manifestation, Cost relates to working memory capacity. The term *Cost* implies that, due to less computer experience, older adults incur higher cost in terms of mental resources when attending to T-M interruptions. More specifically, in gradually replacing resource-intense unusual mental processes by more efficient automatic ones, experience helps to reduce the requirements of cognitive tasks for mental resources (Liu et al., 2004; Strayer & Drews, 2007; Sweller, 1988, 1994). In so doing, experience makes it possible that such distracters as T-M interruptions, once attended to, draw fewer working memory resources away from computer-based tasks, leaving more to meet task demands (Liu et al., 2004).

To illustrate, novice users of such mobile technologies as smart-phones (e.g., the Apple iPhone®) or personal digital assistants (PDA) need to focus a substantial amount of mental resources on operating the device, for example, navigating through the PDA menu (Arning & Ziefle, 2009). Mental resources have to be devoted to identifying the right buttons to push, identifying the right menu items, and maintaining a mental representation of the PDA data structure (Arning & Ziefle, 2009). As a result of these working memory requirements, fewer working memory resources remain available for the actual task of, for example, entering and postponing appointments in the digital diary. However, once PDA users become more experienced, the mental processes involved in operating the device become more automatic, and PDA users become able to maintain a satisfactory mental representation of the PDA data structure with minimal resource requirements (Arning & Ziefle, 2009). Consequently, more mental resources remain available for entering and postponing appointments in the digital diary. However, older people may initially have lower levels of experience to work with than younger.

Similarly, age is a central antecedent to computer experience since older compared to younger individuals tend to be less well educated with respect to technology and perceive technology to be more difficult to use, two important determinants of computer experience (Czaja et al., 2006; Hawthorn, 2007). Consistent with this perception, older adults report substantially lower levels of computer experience than younger individuals (e.g., Czaja & Sharit, 1998; Fisk et al. 2009; Mead et al., 2000; Rogers et al., 1996; Rousseau et al., 1998; Sharit & Czaja, 1999). As a result, older people may need relatively more cognitive resources for adequately performing computer-based tasks and, thus, should have less mental resources to spare for the processing of T-M interruptions. Hence, their effective resource-related cost of attending to T-M interruptions should be higher (i.e., T-M interruptions “steal” a greater amount of resources from the processing of desired content), and they should have fewer mental resources available to meet task demands than younger individuals when T-M interruptions appear. As a result, older adults may perceive higher levels of mental workload when T-M interruptions appear.

In contrast to Cost and Concentration as age-related manifestations, Confidence, which reflects the essence of CSE beliefs (Bandura, 1982; Kahn & Byosiere, 1992), is not related to resource capacity *per se*. Instead, Confidence helps individuals maintain positive thoughts about their ability to successfully accomplish computer-based tasks despite the presence of substantial mental workload. It relates to the general idea that positive thinking can help people deal with stressful events so that the extent to which they manifest themselves in stress is lessened (Lazarus, 1999). Positive thoughts related to the task at hand are particularly effective in countering such threats to task performance as excessive workload. Hence, CSE beliefs (i.e., individuals’ beliefs about their ability to use a computer to accomplish work tasks, Compeau & Higgins, 1995), which are positive in nature and directly related to the performance of computer-based tasks, should weaken the extent to which perceptions of mental workload manifest themselves in stress. In so doing, CSE beliefs assume the role of a coping mechanism.

Since older people adjust their self-efficacy beliefs as their cognitive abilities decline (Bandura, 1994) and computer-based tasks place particularly high cognitive demands on individuals (Birdi & Zapf, 1997), older compared to younger adults consistently report lower levels of self-efficacy with respect to computer use (e.g., Czaja et al., 2006; Laguna & Babcock, 2000; Reed et al., 2005). Hence, on the basis of CSE, older people should cope less well with the mental workload involved in computer-based tasks, implying higher levels of stress for older adults under the condition of mental workload.

Consistent with the P-E Fit perspective, these three user-centric concepts through which adult age impacts technostress influence different links in the causal chain connecting ICTs to individual stress and performance on computer-based tasks. On the one hand, both inhibitory effectiveness and computer experience are concepts that relate to working memory capacity. As such, they moderate the link between the frequency of T-M interruptions and perceptions of misfit between the number of mental resources required and those available for current task performance (i.e., perceived mental workload). On the other hand, CSE assumes the role of a coping mechanism, implying that it moderates the effect of mental workload perceptions on stress. Since older adults have lower levels of inhibitory effectiveness, computer experience, and CSE than younger people, they should benefit less from the moderating impacts of these mechanisms and, hence, be more affected by T-M interruptions.

The fourth C, Capture, which is a technology-centric concept through which age impacts technostress, relates to the notion of stimulus-driven attentional capture. It implies that older compared to younger people may react more strongly to the attentional capture elicited by relatively salient T-M interruptions. Salience is the extent to which such objects as interruptions seem to “pop-out” of the display, increasing the likelihood that they capture individual attention involuntarily (Houghton & Tipper, 1994; Strayer & Drews, 2007). These objects seem to pop-out of the display to the extent to which they are locally unique in some dimension, for example, an orange object among green ones (Yantis & Egeth, 1999). As stimuli become more salient, they are more likely to capture individual attention involuntarily because peoples’ amplification mechanism automatically directs attention toward relatively unique information in, for example, computer displays. Hence, as T-M interruptions become more salient, they are more likely to enter working memory, thereby drawing more mental resources away from the current task (Hasher & Zacks, 1988). Older adults are potentially more receptive to object salience (Fisk et al., 2009), implying they have fewer mental resources available to meet task demands than younger individuals when relatively salient T-M interruptions appear. As a result, older adults experience higher levels of mental workload along with more stress and lower performance on computer-based tasks when T-M interruptions are relatively salient.

The salience of T-M interruptions can be operationally defined in three ways: color-code, dynamism, and auditory alert, all of which are effective in determining an object’s local uniqueness (Strayer & Drews, 2007; Wickens et al., 2004). Color-coding is an effective attentional filtering technique (Yeh & Wickens, 2001) because color can uniquely identify certain objects among others. Consider Skype’s instant messenger as an example; new messages appear in orange, a color that tends to be different from those frequently used in computer displays. The distinction between red and green is particularly salient due to peoples' historic experiences with these colors in human-designed systems, such as dashboards and traffic lights (Wickens et al., 2004). More generally, objects with more reddish colors are associated with greater attentional capture than objects with less (Wickens et al., 2004), since reddish colors have historically served to emphasize importance.

Similar to color-code, dynamism refers to the extent to which objects are emphasized through flashing (Yantis & Jonides, 1990; Yantis, 1993b) or stimuli movement (McLeod et al., 1991; Franconeri & Simons, 2003) as opposed to appearing static. T-M interruptions that appear with flashing or movement are highly distinct from the static nature in which information related to the current task tends to be presented. Since more distinct interruptions are more salient than less distinct ones (Strayer & Drews, 2007; Wickens et al., 2004), such interruptions that appear with flashing or movement are effective in capturing peoples' attention.

Auditory alert refers to the extent to which an appearing object is accompanied by sound effects and, thus, addresses whether T-M interruptions are accompanied by a sound when they appear on the screen. Since aural alerts are highly salient (Strayer & Drews, 2007), T-M interruptions that are coupled with a sound may be particularly likely to capture attention, thereby gaining access to working memory and drawing mental resources away from the current task, particularly for older people.

These various operational aspects of salience often combine in contemporary T-M interruptions (Strayer & Drews, 2007). For example, in the current version (i.e., 4.2.0.169) of the Skype Instant Messenger, instant messages appear coupled with flashing and an aural alert in a reddish color (orange). In so doing, T-M interruptions employ these three operational aspects of salience collectively rather than individually, attempting effective attentional capture.

To summarize the four age-related manifestations on the basis of three user-centric and one technology-centric concept through which adult age impacts technostress, let us briefly recapitulate the *4 C's*. Concentration means that, due less effective inhibition, older people face more trouble concentrating on the current task than younger adults when T-M interruptions appear. Cost implies that older compared to younger adults incur higher resource-related costs when attending to T-M interruptions. Since older people tend to have less experience with ICTs than younger individuals (Sharit & Czaja, 1999), they may need relatively more cognitive resources for adequately performing the current task. Hence, their effective costs of attending to distractions are higher (i.e., interruptions "steal" a greater amount of resources from the processing of desired content). The tem Confidence reflects the essence of self-efficacy (Bandura, 1982; Kahn & Byosiere, 1992), which is lower in older compared to younger adults. Finally, Capture means that older people may react more strongly to stimulus-driven attentional capture than younger adults. In consequence, they could be more affected by relatively salient T-M interruptions. As a result of their disadvantages with respect to the 4 C's, older individuals should incur more stress and lower task performance than younger people when T-M interruptions appear. Figure 3.2 visually represents how these age-related manifestations refine our core model of technostress. Table 3.2 provides definitions for all constructs.

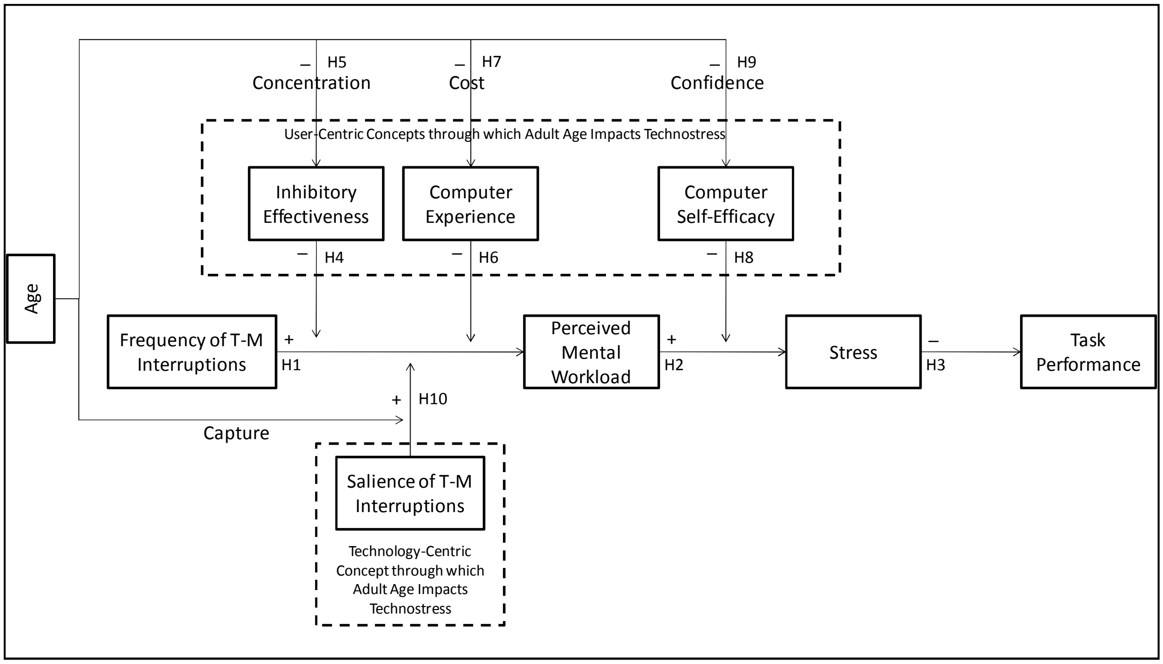
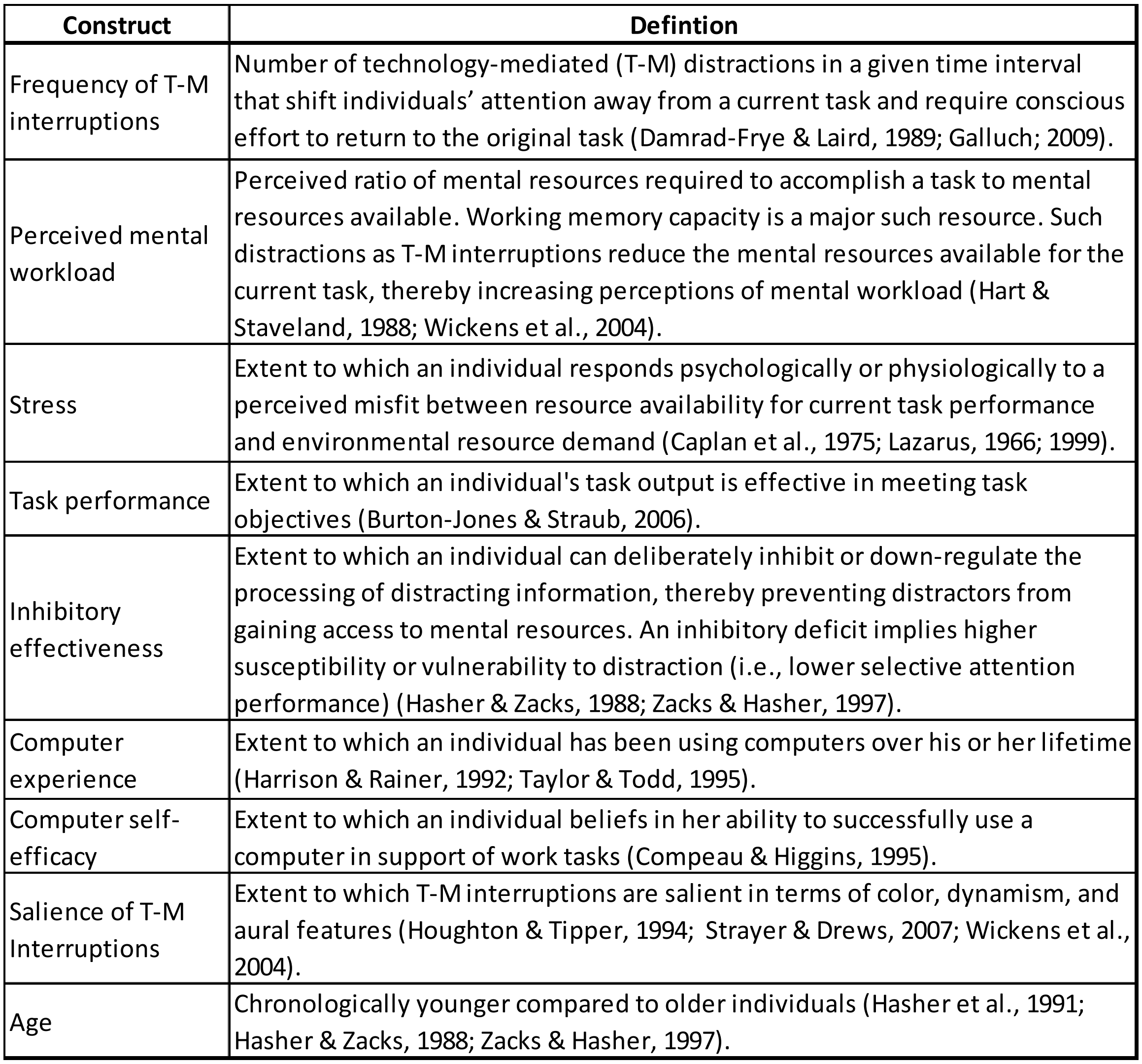


Figure 3.2 Research Model augmented with age manifestations



Construct	Defintion
Frequency of T-M interruptions	Number of technology-mediated (T-M) distractions in a given time interval that shift individuals' attention away from a current task and require conscious effort to return to the original task (Damrad-Frye & Laird, 1989; Galluch; 2009).
Perceived mental workload	Perceived ratio of mental resources required to accomplish a task to mental resources available. Working memory capacity is a major such resource. Such distractions as T-M interruptions reduce the mental resources available for the current task, thereby increasing perceptions of mental workload (Hart & Staveland, 1988; Wickens et al., 2004).
Stress	Extent to which an individual responds psychologically or physiologically to a perceived misfit between resource availability for current task performance and environmental resource demand (Caplan et al., 1975; Lazarus, 1966; 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 distracting information, thereby preventing distractors from gaining access to mental resources. An inhibitory deficit implies higher susceptibility or vulnerability to distraction (i.e., lower selective attention performance) (Hasher & Zacks, 1988; Zacks & Hasher, 1997).
Computer experience	Extent to which an individual has been using computers over his or her lifetime (Harrison & Rainer, 1992; Taylor & Todd, 1995).
Computer self-efficacy	Extent to which an individual beliefs in 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 are salient in terms of color, dynamism, and aural features (Houghton & Tipper, 1994; Strayer & Drews, 2007; Wickens et al., 2004).
Age	Chronologically younger compared to older individuals (Hasher et al., 1991; Hasher & Zacks, 1988; Zacks & Hasher, 1997).

Table 3.2 Construct Definitions

3.4 HYPOTHESES

To formalize the research model, we now turn to developing the research hypotheses depicted in Figure 3.2. We begin by deriving the hypotheses associated with the causal sequence connecting T-M interruptions to individual stress and task performance (i.e., our core or baseline model). Following this, we develop the hypotheses related to the concepts through which adult age impacts our baseline model.

3.4.1 THE T-M INTERRUPTION–STRESS–PERFORMANCE RELATIONSHIP

The stressor–stress–performance relationship is well documented in the organizational stress literature (e.g., Beehr, 1995; Caplan et al., 1975), particularly within the P-E fit perspective (e.g., Blau, 1981). The P-E Fit perspective combined with the extant literature on T-M interruptions indicates that such task demands as T-M interruptions give rise to P-E misfit in the form of mental workload perceptions. These perceptions of mental workload, in turn, increase individual stress, which subsequently reduces individual task performance (Kaldenberg & Becker, 1992; Pervin, 1968; Warburton, 1979). Below, we provide additional arguments and offer specific hypotheses.

T-M interruptions may affect perceptions of mental workload through their impact on the amount of working memory capacity (i.e., the general capacity available for mental work) available for performing computer-based tasks. Working memory capacity is strictly limited, at times to as little as one item (Dumas & Hartman, 2008). More specifically, the storage capacity of working memory is limited to about seven plus/minus two chunks of information (Miller, 1956; Wickens et al., 2004). A chunk refers to a unit of working memory space, where single items can be tied together within a chunk. For example, a sequence of four unrelated letters or digits consists of four chunks of information. By contrast, a sequence of associated letters or digits, such as “Y2K” (i.e., the Year 2000 Problem), tends to consist of only one chunk since it can be coded into a single meaningful unit. Thus, working memory could hold a maximum of seven plus/minus two words or dates. This rigid capacity limitation indicates that distractions, once having gained access to working memory resources, can dramatically reduce the amount of working memory storage capacity available for the current task. This aspect can be illustrated with the notion of a zero-sum game: the resources allocated to the current task are reduced by those devoted to the processing of distracters (Hasher & Zacks, 1988). The more distracters have to be processed per unit time (i.e., the higher the frequency with which such distracters as T-M interruptions occur), the less resources remain available for the processing of task-related information within the time available (Warburton, 1979). In summary, the more frequent such distracters as T-M interruptions enter working memory as a result of having been selected for receiving processing resources, the more capacity is drawn away from computer-based tasks (Hasher & Zacks, 1988), leaving less capacity for the processing of task-related information.

Reduced mental capacity for working on computer-based tasks directly affects perceptions of mental workload (Yeh & Wickens, 1988). For example, poor learning conditions are associated with higher working memory demands than learning without distraction and, thus, increase perceptions of mental workload (Tomporowski, 2003). For T-M interruptions, the more frequently a person encounters them, the more frequently the person will have to decide whether to attend to them and what to think about them, reducing the amount of mental resources available for working on the current task within the time available, while the resource demands of the current task remain unaffected. T-M interruptions, thus, tilt the relative balance of forces between available and required resources over, leading to higher levels of perceived mental workload. Formally:

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

While perceptions of mental workload increase with the frequency of T-M interruptions, they, in turn, are strongly associated with stress (Hart & Staveland, 1988). In fact, a high level of perceived mental workload is a stressor of “particular importance” (Endsley, 1995, p. 53) since it is directly linked to the threat of low performance. As such, the workload–stress relationship has been studied extensively, and workload has been empirically validated as an important job stressor (Friend, 1982).

According to P-E fit theory, high levels of perceived mental workload lead to stress because they reflect insufficient resource supplies to meet task demands (Van Harrison, 1985). As a result of this reflection, high levels of perceived mental workload signal to workers that they lack the basic prerequisite for being productive, implying that they are incapable of meeting task demands (Warburton, 1979). This signal of incapability of meeting task demands may be particularly pronounced for computer-based tasks, which place particularly high mental demands on individuals (Birdi & Zapf, 1997; Czaja & Sharit, 1993; Reed et al., 2005).

By signaling incapability of meeting task demands to individuals, perceptions of mental workload generate feelings of threat, a direct stress-related impulse (Lazarus, 1966; 1999). Threats are expectations of future harm, such as losing one’s job, status within a community, or self-respect (Lazarus, 1966; Van Harrison, 1985). As expectations of harm, threats result in immediate stress. In the context of IS, Beaudry and

Pinsonneault (2005) report on the case of Michele, a clerical worker who participated in their case study. In accordance with P-E Fit theory, Michelle identified a newly introduced information system as a threat to her job security and salary because she felt that the system would increase her mental workload. In consequence, Michelle experienced ICT-induced tension.

Perceptions of mental workload are also directly reflected in frustration, which is strongly associated with stress (Czaja & Sharit, 1993; Hart & Staveland, 1988). For example, because of the great amount of mental resources required for learning, rapid technological change and technological complexity often result in frustration for ICT users, and subsequently lead to technostress (Ragu-Nathan et al., 2008; Tarafdar et al., 2008). Similarly, information overload generated by ICTs may result in frustration and stress (Ragu-Nathan et al., 2008).

Perceived mental workload can lead to several forms of stress, including psychological (e.g., dissatisfaction, anxiety) and physiological stress responses (e.g., high blood pressure and elevated serum cholesterol) (Van Harrison, 1985).[6] Formally:

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[6] While mental workload perceptions may have a curvilinear relationship with individual stress, we focus on the stress resulting from high workload perceptions 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). Some studies suggest that excess supplies generate boredom and fatigue and thereby lead to stress (Beehr, 1995), whereas others indicate that excess supplies have no relationship with stress (Edwards, 1996). Similarly, the information systems and organizational stress literatures often discuss work overload as a major stressor (e.g., Ahuja & Thatcher, 2005; Kahn & Byosiere, 1994), whereas work “underload” is rarely discussed as such. This asymmetry potentially implies that workload is stress-relevant only at higher levels and that low levels of workload have no relevant influence on stress. (This footnote continues on the next page)

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

Stress, whether psychological or physiological (Caplan et al., 1975), has downstream negative consequences. One important organizational consequence of job stress is a reduction in individual task performance (Beehr, 1995). The pathway through stress corresponds to theories suggesting that stress and other experiences of negative affect impact motivation and performance (Lord & Kanfer, 2002). As individuals experience stress, they may devote a large amount of their limited energy to coping with this negative affect rather than working, thereby performing at a lower level. Stress may also result in reduced task performance because people are likely to reduce the effort they devote to their tasks in response to any perceived disequilibrium in the exchange relationship with the person for whom the task is carried out (Lord & Kanfer, 2002). Moreover, individuals often attempt to escape from situations appraised as unfavorable or threatening, thereby performing more poorly (Chang et al., 2009). Further, stress reduces task performance because it quickly mobilizes large amounts of energy (Gaillard, 2008). While such quick and intense mobilizations of energy may be advantageous to physically run away from dangerous situations, they are incongruent with the cognitive processes required for complex tasks, such as most computer-based tasks. As a result of this incongruence, peoples' ability to perform well on these tasks suffers (Gaillard, 2008).

Given this inconclusiveness regarding excess resource supplies, 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 neither had a quadratic relationship with perceived stress ($F(1,116) = 1.156$, $p > 0.05$) nor with hormonal stress ($F(1,118) = 0.174$, $p > 0.05$).

The relationship between stress and task performance has been empirically validated in a variety of studies. Perhaps most importantly, a recent meta-analysis (Chang et al., 2009) confirmed that stress intervenes between stressors and task performance in organizational contexts. Similarly, recent research (Lang et al., 2007) indicated that stress intervenes between stressors and task performance in assessment center settings. Another relatively recent study (Schuette & Jordan, 1996) concluded that stress strongly predicts performance. In the technostress context, two recent studies (Chilton et al., 2005; Tarafdar et al., 2007) found strong negative correlations between stress and performance on computer-based tasks.[7] Formally:

H3: Individual stress is negatively related to task performance.

Since the previous hypotheses fully specify our baseline model of technostress, we can now formally hypothesize the relationships pertaining to age-related manifestations. To refine our core model, we first advance arguments related to user-centric concepts through which age impacts technostress, including inhibitory

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[7] 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., Behr, 1995) hold that arousal may predict task performance trough an inverted, U-shaped curve, others found strong support for a linear relationship. For example, a recent meta-analysis in the management context (Chang et al., 2009) found a strong linear relationship between stress and task performance. Other studies (e.g., Lang et al., 2007) also indicated that stress is linearly associated with performance. In the technostress context, two recent studies (Chilton et al., 2005; Tarafdar et al., 2007) also found strong linear relationships between individual stress and performance. Given this inconclusiveness, proposing a curvilinear relationship may be inefficient. Such a 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 study, post-hoc analyses examining the curvilinear nature of the relationship between stress and performance supported this conclusion. Neither perceived stress ($F(1,119) = 0.000$, $p > 0.05$) nor hormonal stress ($F(1,118) = 1.741$, $p > 0.05$) had a quadratic relationship with task performance.

effectiveness, computer experience, and CSE. Next, we discuss how age may interact with interruption salience to impact ICT-induced stress.

3.4.2 INHIBITORY EFFECTIVENESS AND AGE

Consistent with the literature on selective attention, the Inhibitory Deficit Theory of Cognitive Aging (Darowski et al., 2008; Hasher & Zacks, 1988; Zacks & Hasher, 1997) postulates an attentional inhibition mechanism. This mechanism impacts the amount of working memory capacity available for the processing of current task information by suppressing attentional responses to distracting stimuli. More specifically, an effective inhibitory mechanism directly inhibits or down-regulates the processing of distracting stimuli by preventing distracters from entering working memory. Reduced inhibitory effectiveness is associated with less suppression of response tendencies to distracting stimuli, implying that more distracters can enter working memory. As more distracting information enters working memory due to ineffective inhibition, less working memory resources are available for current-task processing given that the capacity of working memory is strictly limited (Miller, 1956; Wickens et al., 2004). The inhibitory system serves two important complementary functions: access to working memory resources and deletion from working memory (Hasher et al., 1999). While the access function prevents distracters from entering working memory in the first place, the deletion function serves to quickly remove attended-to but rejected information from working memory.

On the grounds that older adults do not have less, but far more information stored in their working memory than younger people, the inhibitory deficit view holds that both access and deletion function of attentional inhibition are compromised in older adults. This can more technically be explained with the changes occurring in the frontal lobe, which houses the inhibitory mechanism (Jurado & Rosselli, 2007). The frontal lobe is the crucial brain component for the holistic organization of intellectual activity, as well as for the programming of intellectual acts and feedback on their performance (Luria, 1973). As people age, the frontal lobe undergoes anatomical changes and so do the frontal lobe's connections with other brain areas. These changes in the brain account for the decline of inhibitory effectiveness (Jurado & Rosselli, 2007). Hence, in older adults, distracting stimuli are more likely to gain access to working memory (access function) and to remain there (deletion function), thereby continuously keeping the amount of mental resources available for the task at hand at a lower level (Zacks & Hasher, 1997).

The inhibitory deficit theory has been widely confirmed in much experimental research (e.g., Carlson et al., 1995; Connelly and Hasher, 1993; Darowski et al., 2008; Hasher et al., 1991; 1999; Kane et al., 1994; Kim et al., 2007; Stoltzfus et al., 1993). Not surprisingly, the theory is considered an important theoretical approach to aging (McDowd & Shaw, 2000; Smith, 1996).

Adding to our core model of technostress, the inhibitory deficit view implies that under the condition of effective inhibition, T-M interruptions are less likely to enter working memory and reduce the amount of mental resources available for working on the current task. More specifically, effective inhibition enables individuals to actively suppress attentional responses to appearing T-M interruptions, thereby preventing such interruptions as instant messages from entering working memory. As a result, T-M interruptions are less likely to affect the amount of mental resources available for working on computer-based tasks. In so doing, inhibitory effectiveness prevents T-M interruptions from tilting the relative balance of forces between the resource available and required for computer-based tasks over. In consequence, inhibitory effectiveness weakens the association between the frequency of T-M interruptions and perceptions of mental workload.

Since older adults have lower levels of inhibitory effectiveness than younger people, they benefit to a lesser extent. Specifically, in older compared to younger individuals, T-M interruptions are more likely to gain initial access to working memory resources, and to continuously absorb mental resources once access has been gained. In so doing, T-M interruptions keep the amount of mental resources available in older adults for computer-based tasks at a lower level. Hence, we specify the following hypotheses:

> *H4: 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.*
>
> *H5: Older compared to younger people have lower levels of inhibitory effectiveness.*

3.4.3 COMPUTER EXPERIENCE AND AGE

It can readily be observed across diverse settings that the behavior performance of novices tends to be slow and effortful, whereas the performance of experienced individuals tends to be fast and effortless (Strayer & Drews, 2007). This phenomenon can be explained through the impact experience has on working memory capacity. As people gain experience with specific tasks, they need fewer mental resources to carry the tasks out. For example, pilot experience helps reduce the amount of cognitive resources necessary for the task of flying (Morrow et al., 2003).This is because working memory capacity is domain-specific and varies with a person's efficiency with the specific task processes (Lee et al., 2007; Liu et al., 2004). As a result, experience in a particular domain can reduce the limitations of working memory capacity (Lee et al., 2007). As noted in our literature review, several complementary arguments have been advanced to explain this proposal.

According to Cognitive Load Theory (Sweller, 1988, 1994), experiences refine and automate the schemata in working memory that link related pieces of information. More specifically, experience gradually replaces resource-intense effortful processes by more efficient automatic processes (Shiffrin & Schneider, 1977). In so doing, domain experience reduces the cognitive burden associated with specific behaviors. Cognitive Load Theory is supported by studies that examine the impact of practice on mental processing (Hasher & Zacks, 1988), the generation of automaticity (Schneider, Dumais, & Shiffrin, 1984), and the acquisition of expertise (Ericsson, Krampe, & Tesch-Romer, 1993) (Tomporowski, 2003).

The impact of experience on the cognitive burden associated with behavior performance has also been explained with the concept of chunking. More specifically, experience enables individuals to process larger chunks of incoming information (Liu et al., 2004). Since the capacity of working memory is strictly limited in terms of the number of chunks that can be processed, but not in terms of chunk length (Miller, 1956; Wickens et al., 2004), forming larger chunks increases the capacity of available resources. This implies that more experienced people have more mental resources to spare for secondary tasks than less experienced adults. As a result, experience helps people manage competing demands for limited cognitive resources (Liu et al., 2004), for example, demands from the current task as well as from T-M interruptions.

Added to our core model of technostress, the above arguments imply that under the condition of accumulated computer experience, fewer mental resources are required to operate the computer and carry out computer-based tasks. This process can be illustrated with the aforementioned example of operating a PDA, where, with experience, fewer resources are required to entering or postponing appointments in the digital diary. Hence, as a result of accumulated experience with computers, T-M interruptions are less likely to draw mental resources away from the processing of current task information. In so doing, computer experience prevents T-M interruptions from tilting the relative balance of forces between the resource available and required for the current task over. Thus, computer experience may weaken the association between the frequency of T-M interruptions and mental workload perceptions[8]. However, older people may benefit less.

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[8] The possibility exists that computer experience also indicates computer confidence (i.e., computer self-efficacy or CSE). More specifically, a person may find that she has performed computer-based tasks successfully in the past and, as a result of this reflection, believes that she can perform well in such tasks. Such a link between computer experience and confidence would imply that computer experience might

Recent research indicates that education and perceived ease of use, both of which differ between older and younger adults, are important determinants of computer experience (Czaja et al., 2006). In general, individuals who have higher levels of education, and perceive computers to be easier to use, are more likely to gain computer experience. Such individuals tend to be younger, for two potentially related reasons. First, adults over sixty years of age tend to be less well educated than younger people (Czaja et al., 2006) since older individuals were educated in times when university educations were less prevalent and higher educations typically limited to the privileged. For example, older workers with at least some college or associate degree accounted for only 53% of that group's employment in 2007, compared to 62% of younger workers (U.S. Bureau of Labor Statistics, 2008). As a result of these differences in education across generations, younger individuals have richer intellectual experiences (Bandura, 1989), particularly with regard to contemporary computing environments.

Furthermore, older individuals were educated in times when technology was far less complex than such current ICTs as smart-phones. As a result, older adults' mental

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indirectly weaken the association between mental workload and stress since our literature review found confidence to potentially act as a coping mechanism. However, as argued in section 2.1.2, there are empirical and conceptual reasons for refraining from modeling such an indirect effect of computer experience. More specifically, empirical support for the relationship between computer experience and confidence has been mixed, with some studies reporting significant correlations between the two concepts (e.g., Harrison & Rainer, 1992; Hasan & Ali, 2004; Laguna & Babcock, 2000) and others failing to find any support for this relationship (e.g., Beckers & Schmidt, 2003; Czaja et al., 2006; Potosky, 2002). Conceptually, there is reason to believe that computer experience and confidence assume distinct roles in a model of technostress since the concepts relate to distinct facets of human cognition. CSE is related to thinking processes and cognitive representations of future events, whereas computer experience is related to the cognitive resource requirements of computer-based tasks. Thus, CSE as opposed 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). For these reasons, we refrained from modeling a relationship between computer experience and CSE in this particular study. However, modeling such a relationship may be meaningful in other study contexts.

models of how technology works, developed in a former time, may not be sufficient for adequate interactions with modern ICTs. In fact, such outdated mental models may even interfere with proper interactions between technology and people (Ziefle & Bay, 2005), thereby reducing the likelihood that older people gain computer experience.

Second, because technology tends to be designed with little systematic regard for the older user, its use is associated with greater difficulty for older compared to younger adults (Fisk et al., 2009). More specifically, there tends to be a large age gap between systems designers, who tend to be younger individuals, and older users (Hawthorn, 2007). Systems designers are often unaware of this age gap (Newell et al., 2006), and implicitly assume a similarity to the user (Hawthorn, 2007). Due to cognitive aging, this implicit assumption breaks down when designing for older people, resulting in systems that are more difficult to use for older compared to younger individuals (Hawthorn, 2007). Consequently, because perceived ease of use is an important determinant of computer experience (Czaja et al., 2006), older individuals should have less experience with respect to computer use than younger people.

This conclusion is unlikely to be an artifact of our time, but rather likely to continue into the future. First, higher education enrollment has generally risen over time, and has done so at a faster rate than the population growth. Accordingly, the percentage of the population participating in higher education increases over time (National Science Foundation, 2010), implying that younger people are more likely to experience university education than older. For example, enrollment rose from 15 million students in 1993 to

19 million in 2007, a trend, which the National Science Foundation expects will continue into the future. Consistent with this notion, the number of college-age people will increase from 22 million in 2010 to almost 30 million by 2050 according to Census Bureau projections, further supporting the continuous nature of this trend (National Science Foundation, 2010).

Second, since the nature of ICTs is continuously evolving and changing at a rapid rate (Benbasat & Zmud, 1999), older peoples' mental models of how technology works will continuously be grounded in the past and, therefore, outdated and potentially incongruent with later technological developments. Similarly, the age-gap between older users and younger systems designers will likely continue into the future given that this gap is relatively substantial and will, therefore, likely exist for systematic, important reasons. More specifically, compared with the rest of the economy, systems designers tend to be very young, with about 85% of all designers being between 25 and 44 years of age (U.S. Bureau of Labor Statistics, 2010). By contrast, less than 2% are older than 65, perhaps because older adults' outdated mental models of how technology works make it more difficult for them to design contemporary systems. In effect, the age-gap between younger designers and older users is likely to continue into the future, implying that ICTs will continuously be more difficult to use for older than for younger people.

Consistent with these arguments, recent research typically reports that older individuals (i.e., people over 60) have less experience with computers than younger people (e.g., Czaja et al., 2006; Czaja & Sharit, 1998; Fisk et al. 2009; Mead et al., 2000;

Rogers et al., 1996; Rousseau et al., 1998; Sharit & Czaja, 1999). Hence, in older adults, T-M interruptions are more likely to draw resources away from the processing of current task information, thereby generating a greater imbalance between demand and availability of mental resources for current task performance. On the basis of these arguments, we specify the following hypotheses:

> *H6: 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.*
>
> *H7: Older compared to younger people have lower levels of computer experience.*

3.4.4 COMPUTER SELF-EFFICACY AND AGE

As noted in our literature review, stress-inducing threat and anxiety emotions arise from mismatches between peoples' perceived capabilities of ensuring positive outcomes and potentially harmful aspects of the situation (Ozer & Bandura, 1990). Hence, people differ in their tendency to experience threat and anxiety as stress emotions on the basis of their confidence in themselves, which is reflected by self-efficacy (Bandura, 1982; Lazarus, 1999). Generally, people high in self-efficacy believe in their ability to meet task demands by mobilizing the cognitive resources and courses of action that these tasks require (Bandura, 1986; 1989). These people also find it easier to dismiss negative thoughts than persons who have a lower sense of personal efficacy. Having a sense of control or mastery over potentially threatening events positively colors the cognitive interpretation of someone's task environment. It makes people optimistic and hopeful, feelings that directly counter potential sensations of threat and anxiety (Bandura, 1997; Folkman & Lazarus, p. 196; Gillham & Reivich, 2007). As a result, task demands present less of a struggle, and treat and anxiety as stress emotions are less likely to occur and will be weaker (Bandura, 1997; Lazarus, 1999). In consequence, people with high self-efficacy are less likely to experience stress than people with lower self-efficacy when such stressors as perceptions of excessive mental workload are present.

Empirical evidence supports the claim that self-efficacy beliefs moderate stressor-stress relationships. For example, recent research reports that people with high self-efficacy show less psychological and physiological stress in the face of such high task demands as work overload than persons with lower efficacy (e.g., Jex & Bliese, 1999; Mossholder et al., 1982; Nauta et al., 2010). Higher levels of self-efficacy are also associated with lower levels of frustration and anxiety (Jex & Gudanowski, 1992). In the domain of ICTs, computer self-efficacy (CSE) is negatively associated with computer anxiety (Czaja et al., 2006; Compeau & Higgins, 1995; Thatcher & Perrewe, 2002; Thatcher et al., 2008) and with such technological stressors as technological complexity (Ragu-Nathan et al., 2008).

According to these arguments, CSE may be effective in helping individuals deal with such psychological stressors as perceived mental workload when performing computer-based tasks. Actually, because performing computer-based tasks necessitates operating the computer, such stressors as perceived mental workload will be far more threatening to those people who do not perceive themselves as capable of operating the computer. Persons with lower CSE may generally feel that computer-based tasks are hostile and that they are helpless. These people might feel threatened even in situations in which persons high in CSE hardly feel threatened at all, because for people with low CSE, dependence on the computer carries with it the implication of threat. Consider Skype VoIP users as an illustration. People who do not believe in their ability to even operate Skype will be far more threatened by the necessity to quickly place an emergency call than persons who are comfortable with operating Skype. The same may apply to users of smart-phones, who, under the condition of low CSE, may be more threatened by the necessity to quickly place an emergency call than smart-phone users with high CSE. Similarly, people who do not believe in their ability to operate a PDA will be far more threatened by the necessity to quickly enter an appointment into the digital diary than persons who are comfortable with operating PDAs.

On this basis, we can conclude that the self doubts inherent in people with low CSE are associated with a stronger link between perceptions of mental workload and stress. Both general and specific CSE may have these implications. For example, individuals with low CSE may feel threatened when any computer use is required or only when they have to use Microsoft Excel®. However, older people may benefit to a lesser extent than younger individuals from the moderating influence of CSE-beliefs.

Recent research indicates that adult age is an important antecedent to CSE (Marakas et al., 1998). In fact, several recent studies found that older adults report lower computer self-efficacy than younger people (e.g., Czaja et al., 2006; Laguna & Babcock, 2000; Reed et al., 2005). This is unsurprising since (1) older people suffer cognitive declines (Hasher & Zacks, 1988), (2) older people adjust their self-efficacy beliefs as their cognitive abilities decline (Bandura, 1994), and (3) computer-based tasks place particularly high cognitive demands on individuals (Birdi & Zapf, 1997; Czaja & Sharit, 1993; Reed et al., 2005). These three aspects combined indicate that adults spiral downward in their CSE beliefs as they age, particularly in such cultures as the U.S. that celebrate youth and negatively stereotype older people so that age becomes an important factor for self-evaluation (Bandura, 1986).

To illustrate, the relationship between age and CSE can be explained on the basis of fluid intelligence, which refers to individuals' ability to learn and adapt in new situations (Pak et al., 2009). As this ability declines with age, older people adjust their self-efficacy beliefs with respect to computer use, which heavily depends on the ability to learn and adapt (Czaja et al., 2006; Pak et al., 2009). Hence, as a result of declining fluid intelligence, CSE suffers. Consistent with this notion, a recent study (Czaja et al., 2006) found that fluid intelligence intervenes in the relationship between age and CSE. More specifically, the results showed that age is a strong negative predictor of fluid intelligence, which, in turn, is a positive predictor of CSE.

Let us consider another illustration that also relates to cognitive declines with regard to learning abilities. More specifically, learning is an important determinant of enactive mastery, which, in turn, is the primary determinant of self-efficacy beliefs (Bandura, 1997). Further, since older adults tend not to have grown up with contemporary ICTs, they depend on their ability to learn about technology even in old age. Hence, as peoples' ability to learn declines with age, so does their ability to develop a sense of enactive mastery about ICTs, implying lower CSE.

This conclusion is unlikely to be an artifact of our time, but rather likely to continue into the future, since cognitive decline is an inherent aspect of biological aging (Hasher & Zacks, 1988) and is of prime importance to self-efficacy judgments (Bandura, 1989). Because people will continue to experience cognitive declines as they age and because computer-based tasks will continue to place cognitive demands on individuals, people will continue to spiral downward in their self-efficacy beliefs as they age. For example, individuals will continue to experience declines in fluid intelligence as they age, implying that their self-efficacy beliefs with respect to computer use, which heavily depends on the ability to learn and adapt (Czaja et al., 2006; Pak et al., 2009), will continue in the future to decline with age. On the basis of these arguments, we specify the following hypotheses:

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.

3.4.5 ATTENTIONAL AMPLIFICATION AND AGE

Attentional amplification implies that relatively salient objects in such visual scenes as computer displays receive processing priority over less salient ones (Houghton & Tipper, 1994; Huang & Pashler, 2005) because constructing their visual representations requires more cognitive resources (Cole et al., 2003). By appealing to individuals’ amplification mechanism, salient objects elicit stimulus-driven capture of visual attention (Cole et al., 2003; Yantis & Egeth, 1999), meaning that they capture attention involuntarily in a bottom-up fashion (Escera & Corral, 2007). Such objects as T-M interruptions do so by being locally unique as a combination of their color, dynamism, and auditory alert (Strayer & Drews, 2007; Wickens et al., 2004).

Color code refers to the color in which stimuli appear in a display. Because of peoples’ past experiences with such human-designed systems as traffic lights and dashboards (Wickens et al., 2004), and because of the relatively rare use of reddish colors, research consistently finds red to be the most salient color, followed by orange, yellow, and green (e.g., Bayot et al., 2008; Luoma et al., 1997; Wickens et al., 2004). This coding scheme is consistent with the color codes used by the American Aviation Community (Wickens et al., 2004) and the U.S. Department of Homeland Security (Rivera et al., 2006). The distinction between red and green is especially salient since human-designed systems have historically reserved red for highly important and green for less important events (Wickens et al., 2004). Consider Skype VoIP or smart-phones as an example. The buttons used to begin a phone call or instant message are typically green, while those used to escape from a call or an unwanted data manipulation are usually red. Thus, if T-M interruptions appear in a salient color like red or orange, they should be more likely to capture attention.

Dynamism through flashing (Yantis & Jonides, 1990; Yantis, 1993b) and stimuli movement (McLeod et al., 1991; Franconeri & Simons, 2003) is also effective in capturing attention involuntarily. Since most information on the screen tends to be static, dynamic objects are often clearly unique and therefore highly salient. Consider internet pop-up advertisements that move across the screen, thereby drawing attention away from the static elements on the display. Further, constructing the visual representations of flashing or moving objects requires more cognitive resources, implying that dynamic objects receive processing priority over static ones (Cole et al., 2003; Strayer & Drews, 2007). More specifically, in contrast to visual representations of static objects, representations of flashing or moving objects have to include the flashing or movement in addition to the information contained in the actual object. Flashing or moving objects on the display may thus contain more information, and thereby capture more attention. Hence, when T-M interruptions appear with flashing or movement, they are more likely to divert mental resources away from computer-based tasks (Strayer & Drews, 2007), leaving fewer cognitive resources for the main task.

Auditory alerts are also salient and can be very intrusive (Strayer & Drews, 2007; Wickens et al., 2004). Consider ringing smart-phones during company, academic, or classroom presentations. Even continuously presented and hence expected irrelevant sounds often remain salient, suggesting that the effectiveness of sounds in capturing attention does not taper off over time (Berti et al., 2004). Consistent with this notion, recent research has provided empirical support that people engaged in visual tasks and instructed to ignore associated auditory stimuli show substantial distraction effects and perform substantially worse when distracting aural stimuli appear (e.g., Andrés et al., 2006; Escera & Corral, 2007; Gumenyuk et al., 2001; 2004). This is even true when participants are being explicitly instructed to ignore distracting sounds and are assured that the sounds' content will not be tested, they still experience substantial disruption (Jones et al., 1999). Hence, when T-M interruptions appear with a sound effect as opposed to without, they are more likely to divert mental resources away from the task at hand (Strayer & Drews, 2007), leaving fewer resources for the current task.

Collectively, color-code, dynamism, and auditory alert can create distraction effects by eliciting three processes (Escera & Corral, 2007): (1) stimulus-driven (i.e., bottom-up) attentional capture by appealing to peoples' amplification mechanism, (2) orientation of attention toward the stimulus, and (3) reorientation of attention toward performance of the main task after a temporary distraction. Hence, once a T-M interruption has captured an individual's attention, the person's attention is drawn away from the main computer-based task and directed toward the interruption, for example, an instant message. After having been temporarily distracted by the instant message, the individual can reorient attention back to performing the main task, a process that requires conscious effort. As a result of this entire procedure elicited by the instant message, fewer mental resources remain available for the main task, while the resource demands of the task remain unaffected. Hence, by appealing more strongly to individuals' amplification mechanism, implying stronger attentional capture effects, relatively salient T-M interruptions should be more likely than non-salient ones to tilt the relative balance of forces between available and required resources over, leading to higher levels of perceived mental workload.

To summarize, since salient display features receive processing priority over non-salient ones (Strayer & Drews, 2007; Wickens et al., 2004) and since older adults may be more affected by salience due to stronger attentional amplification (Fisk et al., 2009)[9], we expect T-M interruptions that are relatively salient by combining an intrusive color with dynamism and an aural alert, to be more likely to gain access to mental resources and impact mental workload perceptions, particularly for older people (see Figure 3.3). Thus:

> *H10: The salience of T-M interruptions and age act as joint moderators in the relation between the frequency of T-M interruptions and perceived mental workload. Hence, we expect a three-way interaction between the frequency of T-M interruptions, the salience of T-M interruptions, and age in the prediction of perceived mental workload. More specifically, 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.*

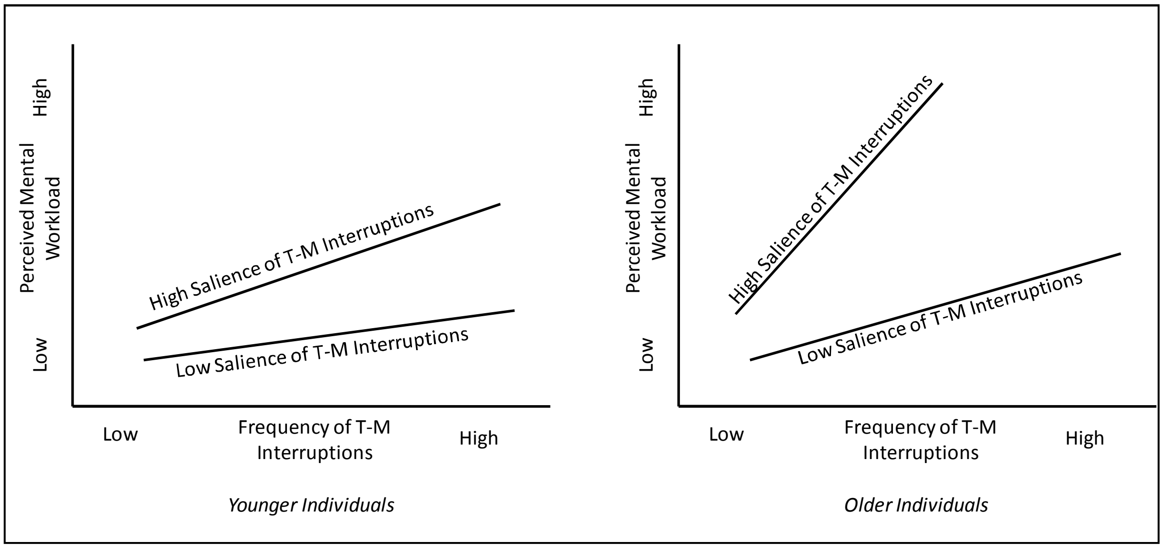

Figure 3.3 Illustration of the three-way interaction among the frequency of T-M interruptions, the salience of T-M interruptions, and adult age predicting perceived mental workload.

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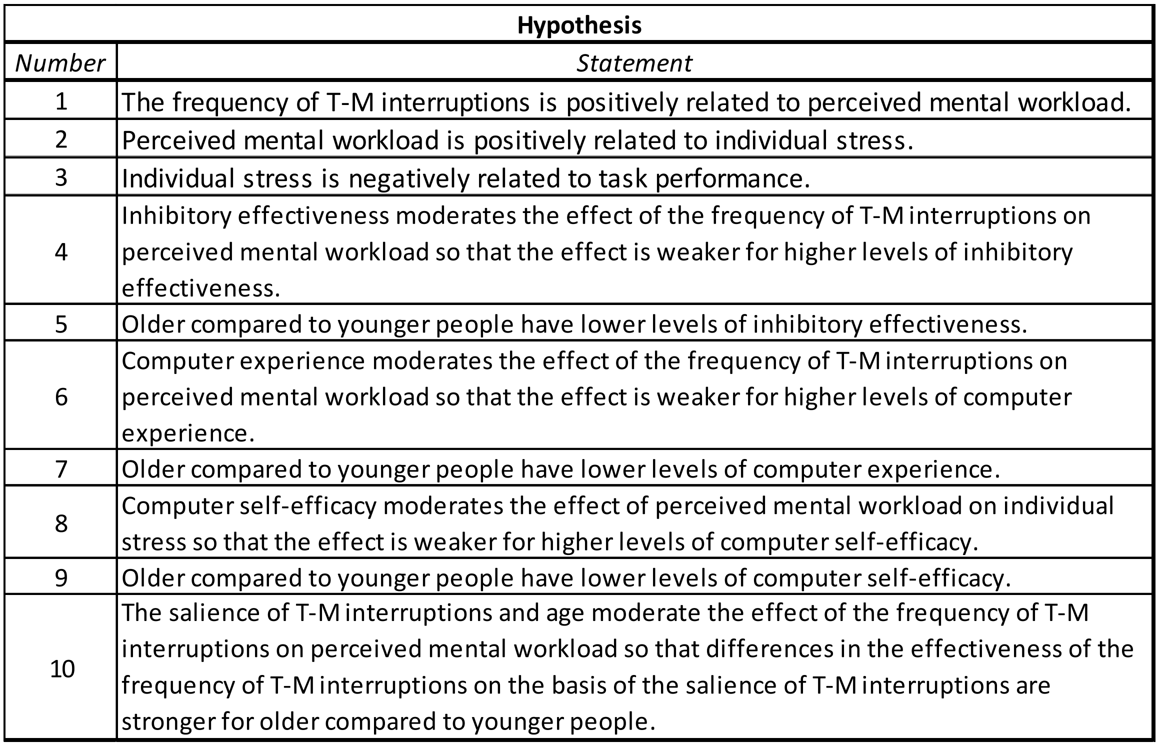
[9] It should be noted that – as discussed in our literature review – the literature is ambiguous as to whether and why attentional amplification increases with age. However, there is empirical evidence (e.g., Pratt & Bellomo, 1999; Whiting et al., 2007) showing that attentional capture effects elicited by salient stimuli are stronger in older adults compared to younger, implying stronger attentional amplification in older adults.

3.5 CHAPTER SUMMARY

In building on a synthesis of the pertinent extant literature, we developed an integrative research model of ICTs, aging, stress, and individual task performance. The research model comprises two main parts: a core model of technostress and pertinent age-related manifestations. The core model connects T-M interruptions to stress and task performance, thereby serving as a baseline for studying relevant concepts through which age impacts technostress. The second part of the model, consisting of age-related manifestations, refines the core model by placing relevant touch points of age along the links in the causal sequence from T-M interruptions to individual stress. Table 3.3 summarizes the hypothesized relationships that comprise our research model.



Hypothesis	
Number	*Statement*
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	The salience of T-M interruptions and age moderate the effect of the frequency of T-M interruptions on perceived mental workload so that differences in the effectiveness of the frequency of T-M interruptions on the basis of the salience of T-M interruptions are stronger for older compared to younger people.

Table 3.3 Summary of Hypotheses

We argue for three points related to the individual user (i.e., inhibitory effectiveness, computer experience, and computer self-efficacy) and one related to the technology (i.e., salience of T-M interruptions) through which age impacts the core model. Together, these four points comprise what we refer to as the “4 C’s”: Concentration, Cost, Confidence, and Capture. More specifically, older compared to younger people (1) suffer from impaired inhibitory effectiveness, thus facing more trouble concentrating on the current task when T-M interruptions appear, (2) have less experience with computers, thus incurring higher resource-related costs from attending to these interruptions, (3) are less confident with regard to computer use and hence less likely to cope effectively with the additional mental workload arising from T-M interruptions, and (4) tend to be more susceptible to high levels of salience of these interruptions. As a result of these four age-related manifestations of differences in individual stress responses to T-M interruptions, older compared to younger individuals’ perceptions of mental workload, well-being, and associated task performance are more likely to suffer when T-M interruptions appear. To empirically test the model, we designed a laboratory experiment that is discussed in the next chapter.

Chapter Four: Experimental Design

4.1 INTRODUCTION

To test the proposed research model integrating ICTs, aging, individual stress, and performance in computer-based tasks, we conducted a laboratory experiment. We deemed an experiment more appropriate than the commonly used survey methodology (e.g., Ragu-Nathan et al.., 2008; Tarafdar et al., 2007; Wang et al., 2008) since this study was the first in the area of age and T-M interruptions and, hence, we were primarily interested in whether the proposed causal relationships indeed existed. Accordingly, for this dissertation, we regarded internal validity as more important than external validity. Using an experiment to test our model was further consistent with prior research in the area of T-M interruptions. For example, Basoglu and Fuller (2007) and Galluch (2009) proposed laboratory experiments to test their models. Similarly, Ren et al. (2008) employed a case study methodology, which could be considered a special case of an experiment (i.e., an experiment with limited scientific control).

This chapter first details the concerns related to the human subjects who participated in our experiment. Following these concerns, it discusses the memory task Concentration as the experimental task used in this study and explains why it was appropriate. Then, the chapter details the procedure in which the experiment unfolded. Next, it provides details on construct measurements, control variables, experimental factors, experimental conditions, and sample size estimates. The chapter concludes with an overview of the pre- and pilot-testing along with the data analytic technique.

4.2 PARTICIPANTS

Since this dissertation focused primarily on establishing causality among the links in the research model, the sample frame was defined broadly. All individuals potentially working with ICTs and facing T-M interruptions were eligible to participate, including university students and older workers as well as retirees from local communities. This was consistent with prior research in the areas of T-M interruptions and age-related differences in distractibility.

Basoglu and Fuller (2007) as well as Galluch (2009) relied solely on student samples to evaluate their models in the context of T-M interruptions. Similarly, Carlson et al. (1995) and Connelly et al. (1991) relied on student samples in the context of inhibitory effectiveness. Hence, students comprised a valid sample frame as representatives of younger adults and, therefore, participated in our experiment. Similarly, older workers and retirees from the community have often served as representatives of older adults. For example, Carlson et al. (1995) and Connelly et al. (1991) relied on older workers and retirees recruited from the community to conduct their study in the context of inhibitory effectiveness.

Since technology-induced stress could have adverse health effects for individuals suffering from elevated stress levels, heart conditions, or high blood pressure (Galluch, 2009), we precluded people with diagnosed elevated stress levels, known heart conditions, or increased blood pressure to participate. In so doing, we not only protected these individuals from suffering health problems but also protected the internal validity of our study. To further protect our participants from adverse effects, we ensured that their participation was strictly voluntary.

Students were recruited voluntarily from undergraduate classes at a large southeastern university by means of email, discussion boards, and announcements. Older adults were recruited from the local community through newspaper advertisements and contacts with one of this dissertation's committee members. In the recruitment process, information was provided regarding the purpose of participation, associated risks, and incentives.

The purpose was defined broadly as enhancing understanding of employee well-being and performance on computer-based tasks in the context of workplace stress. The participants were further informed of the risk of temporary discomfort resulting from elevated stress levels and the collection of salivary measures. They also were informed that the degree of discomfort they might encounter would be comparable to the level of discomfort employees generally experience in the workplace. Subjects were instructed that participation was entirely voluntary and that they could withdraw their consent for participation whenever they pleased.

Incentives included monetary compensation, the chance to win an Apple TV, a Nintendo Wii, or an Amazon Kindle, and enjoyment. First, across younger and older individuals, monetary compensation for participation totaled US$ 15. Second, participants were entered into a drawing for the Apple TV®, Nintendo Wii, and Amazon

Kindle based on their performance on the experimental task. Finally, the experimental task was an enjoyable one.

In an attempt to further ensure subject well-being during the experiment, the principal investigator became certified as a Group 1 Investigator Conducting Social and Behavioral Science Research by completing a comprehensive IRB training. The training included modules on particularly vulnerable subjects, regulations, fundamental issues, and the history as well as ethics related to the use of human subjects in research. Further, the training encompassed such additional topics as how to identify underage participants.

4.3 EXPERIMENTAL TASK

Since our theory argues that T-M interruptions reduce the mental resources available for task performance by entering working memory, thereby interfering with current task processing, the task had to demand substantial working memory resources and sustained attention. More specifically, the task had to be designed in such a way that T-M interruptions quickly and substantially reduced the working memory capacity available for the task and easily interfered with task-related information processing. Combining these aspects suggested a task that required information processing over prolonged periods of time under extensive utilization of information held in working memory. Hence, a memory task involving sustained attention was required.

The task had to be accomplished under time pressure to enhance sustained attention requirements (Strayer & Drews, 2007), had to be engaging and absorbing to enhance intrinsic motivation (Washburn, 2003), had to be suitable for both older and younger adults, and had not to require extensive explanation or training that would have exhausted the limited availability of the subjects' and investigators' time and other resources. Further, the task had not to be a stressor in and of itself; stress had to arise from the T-M interruptions, not the task (see Table 4.1).

#	**Description**
1	An extensive amount of information must be held in working memory and used to make decisions
2	Attention must be sustained so that interruptions can be distracting
3	There must be some time pressure to enhace sustained attention requirements and the relevance of interruptions
4	The task needs to be engaging and absorbing to enhance intrinsic motivation and sustained attention, respectively.
5	No extra directions and no special knowledge should be required
6	The task needs to be suitable for both older and younger adults
7	The task ought to be demanding, but not stressful in and of itself

Table 4.1 Criteria for Task Selection

To identify an appropriate memory task involving sustained attention, we examined game-like computerized tasks that had been used successfully in prior research on cognitive functioning. Game-like computerized tasks generally offer many benefits for experimental research (Washburn, 2003; Washburn & Gulledge, 1995). They are intrinsically motivating and, hence, elicit motivated performance, and they provide continuity and context for responding. Perhaps most importantly for the research conducted here, game-like computerized tasks are very useful for bridging age-related differences in experimental settings since they tend to attract participation across such demographic boundaries as age (and even across species) (Washburn, 2003). We considered three distinct game-like computerized tasks that fell into at least one of two categories: memory and sustained attention. The three considered tasks were the memory tasks Concentration (e.g., Washburn et al., 2007) and Anagram (Sagarin et al., 2003), and the sustained attention task "Jumpers" (Dabbish & Kraut, 2008).

The online browser memory game Concentration had been used successfully as a task in past research on age-related differences in cognitive functioning (e.g., Baker-Ward & Ornstein, 1988; Schumann-Hengsteler, 1996); Concentration is particularly useful for bridging age-related differences in experimental settings since the game is generally participated-in by people of all ages (Washburn & Gulledge, 2002). Due to this characteristic, Concentration may be particularly appropriate for examining age-related differences in technostress.

In the Concentration game, the players generally have to find matching pairs of symbols by flipping computer-generated cards. In the process, they have to memorize the symbols they have seen and where the symbols are hidden. The game starts with a 4 x 4 matrix of cards with a symbol on one side and exactly two cards having the same symbol. The cards are presented face down to an individual, who alternately flips two cards for every trial (i.e., one move). In case the two uncovered symbols are not identical, both cards are returned to their face down position. Once the individual detects a matching pair of cards, the cards can be left in a face up position. The game ends once all eight matching pairs are uncovered.

To find all matching pairs under time pressure, the players have to remember what symbols have been revealed and where they are positioned in the matrix. Hence, the Concentration game can be considered an explicit 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 & Gulledge, 2002; Washburn et al. 2007). For scientific purposes, the working memory demands of Concentration can easily be modified to fit the study context (Eskritt et al., 2001; Washburn et al. 2007) by varying the number and nature of pairs of symbols to be memorized. Not surprisingly, Concentration has proven useful as a task in several studies on working memory (Washburn et al. 2007).

As an experimental task, Concentration generally fulfills all of the criteria outlined in Table 4.1. A large amount of information must be held in working memory and used to decide what card to turn over next (Schumann-Hengsteler, 1996; Sturm et al., 2004; Washburn et al. 2007). Sustained attention is required since the final score is based on the number of matching pairs of cards found within a given time period; hence, to perform well, people have to sustain attention in case they intend to find all matching pairs under time pressure. Since the time available to find all matching pairs can be freely set by the investigator, time pressure can easily be incorporated into the design of Concentration. Further, Concentration is engaging and absorbing (Washburn, 2003; Washburn et al., 2007), and it motivates high performance (Eskritt et al., 2001; Washburn, 2003), ensuring that lack of motivation does not bias the link between mental workload perceptions and individual stress.

Moreover, Concentration is well known by people of all ages (Schumann-Hengsteler, 1996; Washburn & Gulledge, 2002) and very simple (Eskritt et al., 2001; Washburn et al., 2007), implying that it is suitable across age groups and rendering extensive training and special knowledge unnecessary. In fact, even monkeys can understand the rules and act accordingly (Washburn et al., 2007).[10] Finally, because the working memory demands inherent in the Concentration task can be varied by the investigator (Washburn et al. 2007), the task can be designed in such a way that it is demanding, yet not stressful in and of itself.

Another relevant memory task that has been applied to experimental research on cognitive functioning is the game Anagram. An anagram is a word puzzle consisting of a series of scrambled letters that can be re-ordered to form words. For instance, “rmcputoe” can be re-ordered so that it forms the word *computer*. Similar to Concentration, solving anagrams is cognitively demanding (Sagarin et al., 2003). The participants have to mentally transform a series of letters and to compare these potential solutions to known words in memory. Accordingly, information must be held in working memory and used to make decisions. Researchers can easily vary the level of difficulty inherent in this task by manipulating the number of letters. While five letter anagrams can be considered difficult, four letter ones can be solved easily (Sagarin et al., 2003).Further, solving

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[10] Task suitability for both age groups does not imply that performance in the experimental task is generally equal across the age groups. We make no assumption about a potential direct effect of age on performance in the experimental task since such a potential age-related difference in task performance may not affect the causal links proposed in our research model. For example, a direct effect of age on performance cannot be expected to affect the stress-performance link so that a larger/smaller manifestation of stress in performance results. Rather adult age and stress may have distinct and independent main effects on performance in the experimental task.

However, it deserves mentioning that research comparing the performance in the Concentration task between adults and children found that task performance is independent of age (Schumann-Hengsteler, 1996). For example, Baker-Ward and Ornstein (1988) compared the performance of children with an average age of 8 years to the performance of adults with an average age of 20 years and fond no age differences in overall performance. Similarly, Gellatly et al. (1988) compared the performance of children with an average age of 7 years to the performance of adults in their twenties and thirties and fond no age differences in terms of memory performance.

Still, given the general declines of cognitive abilities with advancing age, at least small age-related differences in performance on this task seem intuitively plausible. However, as argued above, such differences should not call the adequacy of this task into question.

anagrams requires visual attention to the center of the computer display, but only for a fraction of the time necessary to solve the anagram (Sagarin et al., 2003). Hence, sustained attention is not an explicit requirement of the Anagram task.

However, solving anagrams is engaging. In a recent study that utilized this task (Sagarin et al., 2003), the participants evaluated anagrams as enjoyable (mean of 3.81 on a scale ranging from 0 (not at all) to 6 (very much)). Further, the Anagram task appears to be relatively simple, implying that extensive training and special knowledge may be unnecessary. The question of whether this task is suitable across age groups in terms of task familiarity and attractiveness cannot unambiguously be answered, however, since prior research is silent on this issue.

A relevant sustained attention task is the Jumpers video game (Dabbish and Kraut, 2008). In this game, which is a variation of the classical “Jump and Run” game, the players have to save people jumping from a building by catching them on a stretcher and bringing them to an ambulance. Each jumper constitutes an independent subgame and performance is determined by the number of jumpers saved.

The game requires the players to sustain their attention on the screen so that many jumpers can be saved. However, since the players merely have to move a stretcher around in a two-dimensional space, Jumpers does not demand substantial working memory resources. Specifically, no information has to be held in working memory and used to make decisions. Still, the game imposes time pressure on the players since the jumpers have to be saved before reaching the ground. Furthermore, the game appears to be engaging and absorbing and relatively simple. Special knowledge does not seem to be required. However, the question of whether Jumpers is suitable across age groups in terms of familiarity and enjoyment cannot unambiguously be answered since past research is silent on this subject. The number of jumpers can be adjusted by the researcher to ensure that – as a task – the game is demanding, yet not stressful by itself.

Table 4.2 maps the characteristics of Concentration, Anagram, and Jumpers onto the criteria for task selection to enable a formal comparison of the tasks. The comparison reveals that Concentration is optimal as it meets all seven criteria, while Anagram and Jumpers are suboptimal since they meet only 71% of the criteria for task selection when being evaluated conservatively. In line with prior research, the Anagram game may be more appropriate for experiments that do not manipulate age and do not require continuous, focused attention (Sagarin et al., 2003). Such experiments may focus on evaluating memory retrieval among college students. The Jumpers game may be more appropriate for experiments that do not manipulate age and do not focus on working memory. Such experiments may focus on evaluating how college students interact in teams (Dabbish & Kraut, 2008). We concluded that Concentration was the most appropriate game-like computerized task for this particular study. Accordingly, Concentration was used in the experiment.

Criterion		Concentration 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 used to make decisions**	✓	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 has to be held in working memory and used to make decisions. The participants merely have to move a stretcher around (Dabbish & Kraut, 2008)
2	**Attention must be sustained on the screen so that interruptions can be distracting**	✓	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 attention on the screen so that many jumpers can be saved
3	**There must be some time pressure to enhace sustained attention requirements and the relevance of interruptions**	✓	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**	✓	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
5	**No extra directions and no special knowledge should be required**	✓	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**	✓	The task bridges age-related differences since it tends to attract the participation of younger and older adults, 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 for both older and younger adults cannnot unambiguously be answered.	?	Research examining the suitability of this task across age-groups is nascent. Hence, the question of whether this task is suitable for both older and younger adults cannnot unambiguously be answered.
7	**The task ought to be demanding, but not stressful in and of itself**	✓	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%	
Legend: CM = Criterion met.							

Table 4.2 Comparison of the Concentration, Anagram, and Jumper Tasks

The challenge for researchers is transforming computerized games into computerized tasks without sacrificing the tasks' engaging and absorbing nature (Washburn & Gulledge, 1995). In the case of this dissertation, the rules of Concentration did not have to be modified, leaving the nature of the task with its positive impacts on experimental research intact.[11] However, the Concentration task needed to be modified in terms of its working memory demands and the appearance of T-M interruptions.

To ensure that T-M interruption could quickly and substantially reduce the working memory capacity available for the Concentration task and easily interfere with the information processing necessary for the task, the task's working memory demands had to be close to subjects' working memory capacity. Hence, instead of simply using the traditional version of Concentration with simple pictures or words as symbols that are identical on two cards (e.g., "iPhone" and "iPhone") and that may not be overly working memory demanding, we hired a highly qualified computer programmer with knowledge of Information Systems research to customize Concentration to the requirements of this study. The Concentration task employed in this study used arithmetic with specifically designed playing cards instead of pictures. One card contained an integer number, and another matching card contained a multiplication that yielded this integer number. For example, a matching pair of cards could have consisted of one card with the symbol "48" and another card with the symbol "12 * 4." The objective of this computerized task was to find as many matching pairs as possible within the given time frame. Once a matrix of cards was entirely uncovered, another one appeared automatically and so on until the

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[11] We admit that the computer aspect of this task may be contentious. For example, some might argue that computer experience and CSE may become confounded with the computer aspect of the task. However, consistent with the ideas presented here, prior experimental research in IS (e.g., Yi & Davis, 2003) has evaluated such constructs as CSE using computer-based tasks. More importantly, we believe that the ability of individuals to deal with distractions is a general capacity that transcends specific environments. Likewise, given that computer experience and CSE are general capacities, we believe that these constructs operate universally across research settings.

time frame was exhausted. While the participants were working on this computer-based task, T-M interruptions appeared on the computer display (see Figure 4.1).

Sender says: 32+33=65

Sender says: 48+48=96

Sender says: 21+22=43

Sender says: 41+42=83

>> Player 1 << Number of tries: 1, Time: 0

Figure 4.1 Illustrative Interface

To ensure that T-M interruptions were intrusive and that attentive responses to them difficult to inhibit, the content of interruptions was meaningfully related to the Concentration task. Each interrupting object contained an equation in the form of “48 + 48 = 96.” However, to prevent any confounding effects of the content of interruptions on performance, the equations provided in the actual problem and in the interruption did not match. Content-wise, interruptions were entirely irrelevant for the particular sets of cards participants were working on. Thus, attending to the equations given in the interruptions did not help participants’ performance. Cards and interruptions were drawn at random.

T-M interruptions appeared on the screen within specific time intervals, for example, one set of interruptions every 10 seconds. These intervals and the set size (i.e., interruption complexity or the number of simultaneously appearing interruptions) were calibrated by means of a pre-test, whose results are discussed in the next chapter. Over the course of the task, T-M interruptions appeared randomly at different locations on the screen since predictability of spatial location offsets the usual disadvantage older people face in their ability to inhibit.

4.4 EXPERIMENTAL DESIGN

In accordance with our theoretical model, the experiment included three factors (age, frequency of T-M interruptions, and salience of T-M interruptions) with two levels each. Table 4.3 shows the resulting six 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

Table 4.3 Experimental Selections and Manipulations

These six experimental selections and manipulations were associated with a 2 x 2 x 2 mixed-model design. Adult age (younger and older) and the frequency of T-M interruptions (lower and higher) were used as between-subjects variables. Within each age group, the participants were subdivided into those being presented with a higher frequency of T-M interruptions and those being presented with a lower one. Within each of the resulting four groups, the subjects were presented with each of two conditions for the salience of T-M interruptions (higher and lower salience), with the order of presentation counterbalanced across participants within each of the four groups. Table 4.4 details the experimental conditions resulting from this design:

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)
Legend: Numbers in parentheses represent the identifiers assigned to the conditions.								

Table 4.4 Experimental Conditions

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 3-way interaction corresponding to hypothesis ten.

The experiment employed a pre-post design (Cook & Campbell, 1979) with random selection and assignment of subjects to the eight experimental conditions (see Table 4.5). After the subjects were assigned at random to the conditions, the baseline measures of sAA were taken. Following the collection of the baseline measures, the treatments corresponding to the experimental conditions were applied. Finally, the post-task measures of sAA were taken. Using this pre-post design increased the internal validity of our study by enabling us to include the pre-condition measure as an additional control variable in the study.

Condition	Assignment Type	1st Outcome Measurement	Treatment Application	2nd Outcome Measurement
1	R	O	X_{111}	O
2	R	O	X_{112}	O
3	R	O	X_{121}	O
4	R	O	X_{122}	O
5	R	O	X_{211}	O
6	R	O	X_{212}	O
7	R	O	X_{221}	O
8	R	O	X_{222}	O
Legend: R = Random Assignment of Subjects to Conditions; O = Outcome measured; X = Treatment applied (numbers correspond to factor levels; order: Age, Frequency of T-M interruptions, Salience of T-M interruptions)				

Table 4.5 Experimental Design

To estimate the number of subjects needed for this pre-post design to yield adequate statistical power, we conducted a power analysis. The number of experimental conditions (eight in this case) provided the basis for the power analysis, which involved assumptions concerning the effect size in the population, the desired level of statistical power, and the correlations among the repeated measures. In general, the population effect size can be classified as small, medium, or large, with the recommended sample size decreasing as one moves from small to large (Cohen, 1988; Cohen et al., 2003). As regards the desired level of statistical power, the general consensus is that a power of 0.80 is appropriate.

The correlation between our repeated measures also needed to be taken into consideration since we employed a within-subjects design, with the participants experiencing both higher and lower salience of T-M interruptions. The correlation coefficient among repeated measures is generally assumed to be 0.50 (Cohen, 1988); however, for reasons of conservatism, this dissertation assumed a correlation of zero.

We used G*Power 3.1 (Faul et al., 2009), a flexible statistical power analysis software package for the social and behavioral sciences, to estimate the required sample size. Before specifying any input parameters, we selected Repeated Measures ANOVA for Testing Within-Between Interactions as the statistical test. This test was chosen to enable testing for the 3-way interaction among age (a between factor), the frequency of T-M interruptions (a between factor), and the salience of T-M interruptions (a within factor).

Following this selection, we specified the following input parameters: 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. Figure 4.2 shows the relationship between statistical power and sample size for the specifications made. The results indicate that a sample size of 90 participants would be adequate. However, to account for the potential non-usability of up to 40% of the data, we aimed for a sample size of at least 125 participants.

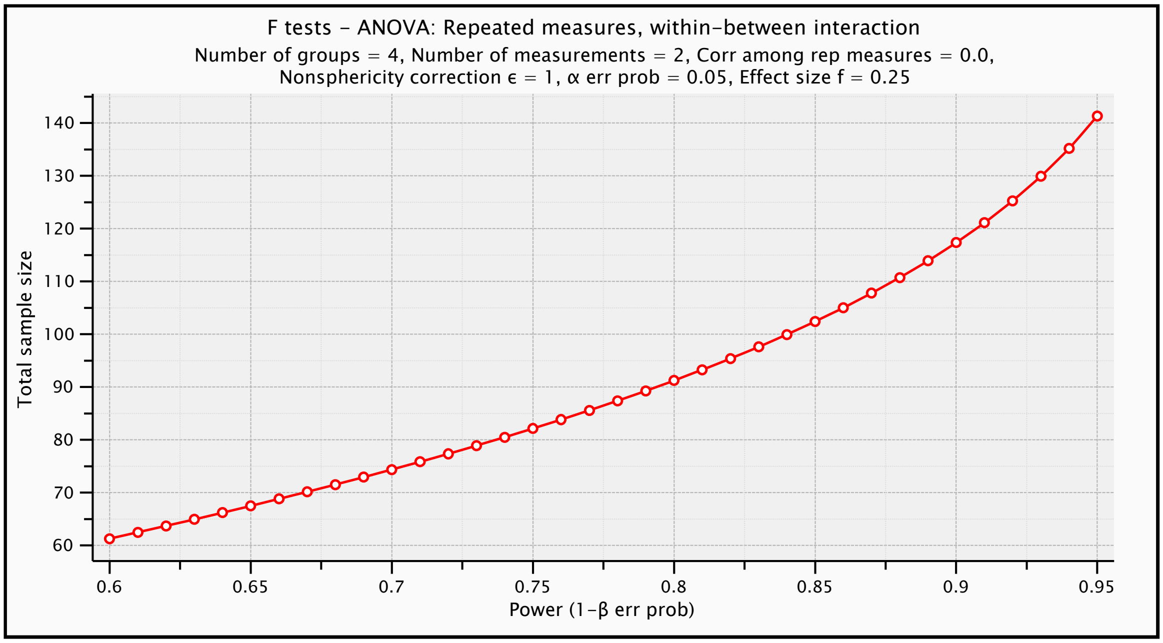


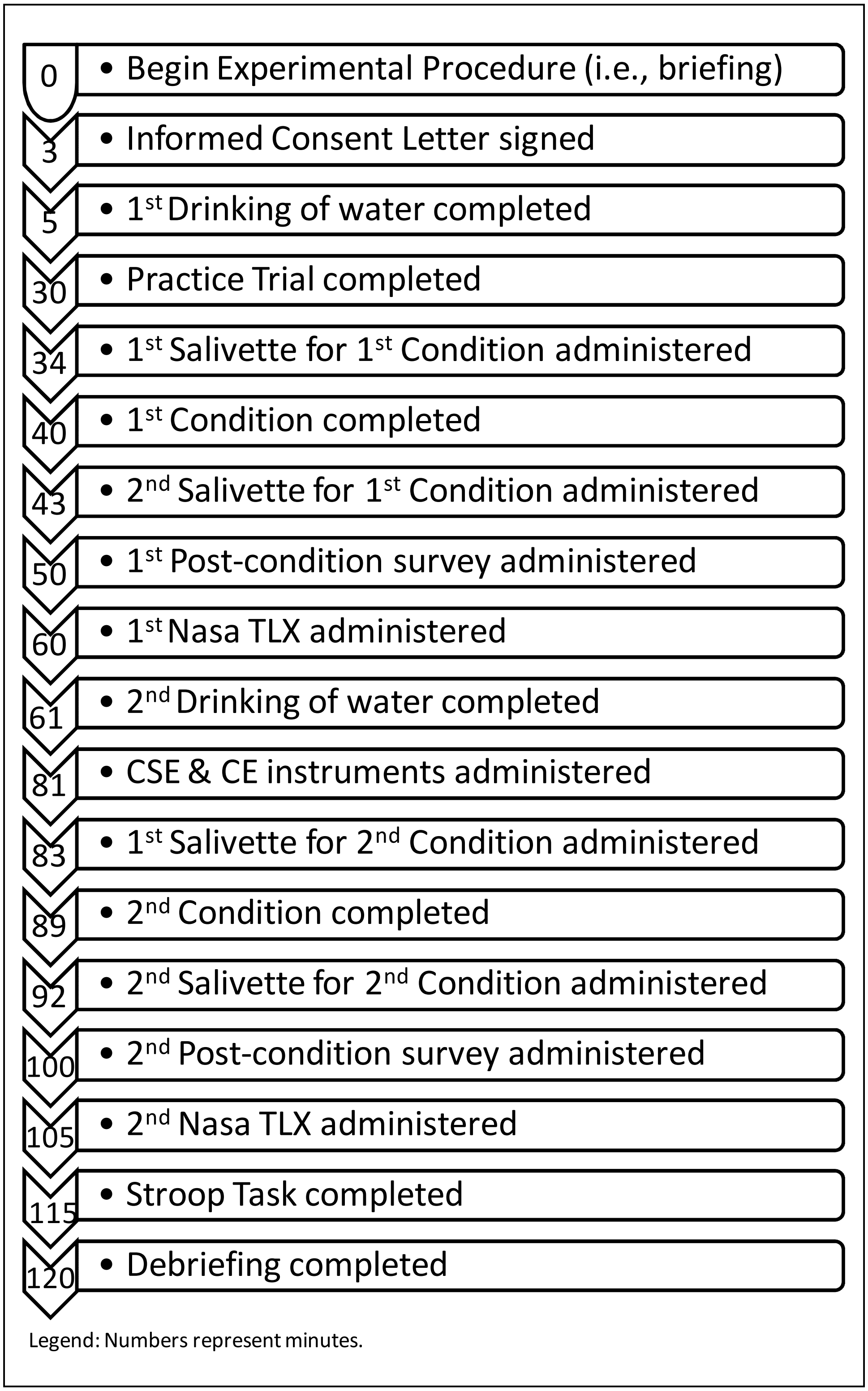
Figure 4.2 Total Sample Size as a Function of Desired Power

4.5 EXPERIMENTAL PROCEDURE

Upon entering the laboratory, the participants were informed of their rights and voluntarily signed the approved Informed Consent Letter. To encourage focused attention on the task above and beyond its motivating nature, the participants were also asked to provide counterfeit names (e.g., “Kindle45”), which were subsequently used to compile a performance-based ranking per each age group that was sent to all participants once the study was completed (Yi & Davis, 2003). Ranking participants within their age groups increased the competitive nature of the task and made participation more meaningful.

Following this procedure, the participants drank some water to help prevent a possible contamination of the objective stress measure, which was salivary. The Concentration task started with a short instruction on the task’s rules (Schumann-

Hengsteler, 1996). The subjects were also instructed to ignore appearing T-M interruptions so that they would rely more heavily on their inhibitory mechanism. They were also informed that they would participate in two conditions. After these instructions, the subjects engaged in a practice trial of the Concentration task (Eskritt et al., 2001). Figure 4.3 presents an outline of the experimental procedure.



Legend: Numbers represent minutes.

Figure 4.3 Outline of the Experimental Procedure

Following the introduction of the task, the baseline salivary measure for condition one was taken and participants began working on the first condition. This condition consisted of an infinite number of matrices generated at random by a computer algorithm that the participants could solve within a given time period. Upon completion of the task, the second salivary stress measure was taken, followed by a post-condition survey (including the manipulation checks), the measure for perceived mental workload, and the measures for computer experience and computer self-efficacy. The administration of these measures took a minimum of 20 minutes, which is the time frame necessary for salivary measures of stress hormones to return to their baseline levels after task completion (Granger et al., 2007).

Following the administration of these measures, the baseline salivary measure for condition two was obtained and the participants began working on the second condition. After completing the task, the second post-condition salivary measure was taken, followed by the post-condition survey, the scale for perceived mental workload, and the measure for inhibitory effectiveness. The experimental procedure ended with a debriefing, in which participants could ask additional questions. Figure 4.4 depicts the flow of the major experimental activities.

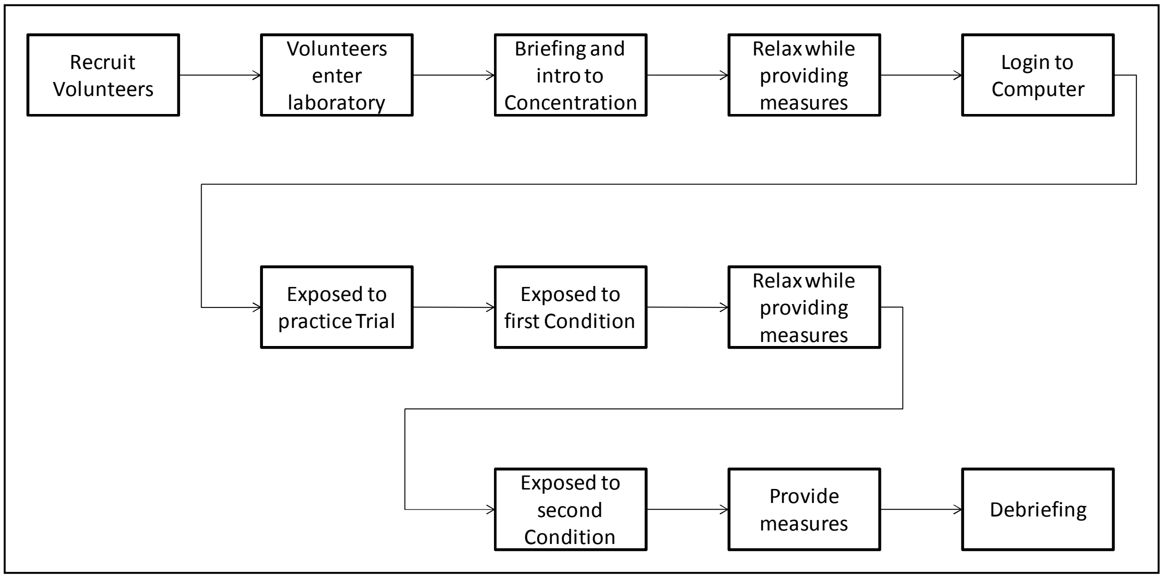


Figure 4.4 Flowchart of the Experimental Procedure

4.6 MEASURES AND MANIPULATIONS

The following subsections detail the perceptual measures, psychological tasks, and experimental manipulations employed in the experiment. In line with the development of our research model, we first discuss the measures and experimental manipulations pertaining to our core model of technostress, before turning to those relevant to the age-related manifestations.

4.6.1 MEASURES PERTAINING TO THE CORE MODEL OF TECHNOSTRESS

The following subsections discuss the experimental manipulation for the frequency of T-M interruptions, the NASA Task Load Index as a measure of perceived mental workload, the subjective and objective measures for individual stress, and the objective measure for performance on the Concentration task.

4.6.1.1 The Frequency of T-M Interruptions

The frequency of T-M interruptions refers to the number of T-M distractions in a given time interval that shift individuals' attention away from a current task and require conscious effort to return to the original task (Damrad-Frye & Laird, 1989; Galluch; 2009). In accordance with the P-E Fit perspective, we manipulated this frequency through 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, which constituted our focal interest. The frequencies of interruptions pertaining to lower and higher were adjusted by means of a pre-test, whose results are presented in the next chapter. Table 4.6 shows the perceptual manipulation check for the frequency of T-M interruptions.

Item #	Item
IF1	Interruptions appeared very frequently during the task.
IF2	Numerous interruptions appeared over the course of the task.
Scale Range: 1 = Strongly Disagree; 4 = Neutral; 7 = Strongly Agree	
Stem: For each of the statements below, please indicate your estimate of the frequency with which interruptions appeared during the memory task by selecting the appropriate response.	
In addition, please estimate the number of interruptions you received during the entire memory task.	

Table 4.6 Items for the Frequency of T-M Interruptions

4.6.1.2 Perceived Mental Workload

Perceived mental workload refers to the perceived ratio of mental resources required to accomplish a task to mental resources available (Wickens et al., 2004). Assessment tools for mental workload perceptions should possess a number of useful properties, including selectivity, sensitivity, diagnostic capabilities, reliability, ease of implementation, and low intrusiveness (Eggemeier, 1988). The NASA Task Load Index (TLX; Hart & Staveland, 1988), which is a major assessment tool for mental workload perceptions, has been shown to meet these criteria (Rubio et al., 2004). In particular, it is easy to administer and, thus, is not perceived as intrusive by subjects (Hart & Staveland, 1988). This is an important property since it allows the researcher to isolate stress effects on the basis of T-M interruptions. Hence, this study used the NASA TLX, which has been well-validated as a measure of perceived mental workload (Cao et al., 2009).

The TLX is a comprehensive and multidimensional subjective measure (Cao et al., 2009; Noyes & Bruneau, 2007). It derives an overall workload score from a weighted average of ratings on subscales for mental demand, physical demand, temporal demand, performance, effort, and frustration level. While the first three subscales relate to the demands imposed on the person (mental, physical, and temporal demand), the latter relates to the interaction between the person and the task (performance, effort, and frustration level).

This index returns one total score along with six scores for the individual dimensions of Mental Demand, Physical Demand, Temporal Demand, Effort, Performance, and Frustration (Cao et al., 2009; Noyes & Bruneau, 2007). Particularly salient dimensions can dominate others in the overall workload rating (i.e., if workload results from one or more particularly salient dimensions, other dimensions may not contribute as much to the workload perception). Further, the six subscales provide relatively independent information about the workload imposed (Hart & Staveland, 1988).

The TLX uses a two-step process; subjects assign both ratings and weights to subscales (Cao et al., 2009; Noyes & Bruneau, 2007). Once the experimental task is completed, the subjects assign weights on the basis of relevance for workload to each subscale. This evaluation is based on 15 pair-wise combinations of the subscales. Afterward, subjects assign a value between 0 and 100 (least to most taxing) to each subscale. These ratings reflect the magnitude of the dimensions. Multiplication of each raw rating with the corresponding weight yields the overall workload score for each dimension. Finally, the absolute workload score is obtained by dividing the sum of the weighted ratings by the sum of the weights (which is 15). The absolute workload score lies between 0 and 100 (Cao et al., 2009; Noyes & Bruneau, 2007). The entire test takes approximately three minutes to be completed (Hart & Staveland, 1988). Figure 4.5 shows operational definitions for the subscales and an example.

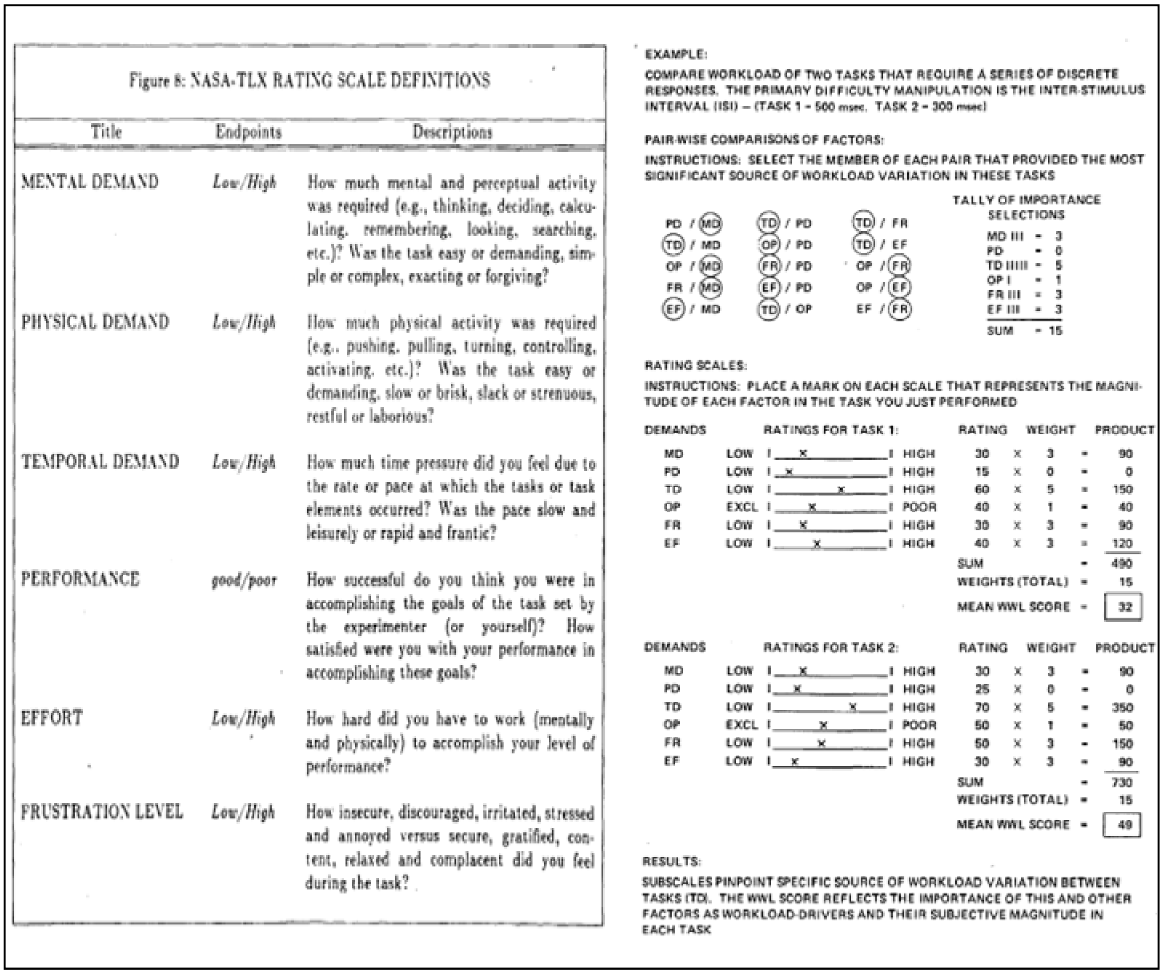


Figure 8: NASA-TLX RATING SCALE DEFINITIONS

Title	Endpoints	Descriptions
MENTAL DEMAND	*Low/High*	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	*Low/High*	How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	*Low/High*	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	*good/poor*	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
EFFORT	*Low/High*	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION LEVEL	*Low/High*	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

EXAMPLE:

COMPARE WORKLOAD OF TWO TASKS THAT REQUIRE A SERIES OF DISCRETE RESPONSES. THE PRIMARY DIFFICULTY MANIPULATION IS THE INTER-STIMULUS INTERVAL (ISI) – (TASK 1 = 500 msec. TASK 2 = 300 msec)

PAIR-WISE COMPARISONS OF FACTORS:

INSTRUCTIONS: SELECT THE MEMBER OF EACH PAIR THAT PROVIDED THE MOST SIGNIFICANT SOURCE OF WORKLOAD VARIATION IN THESE TASKS

PD / [✓ MD]
[✓ TD] / MD
OP / [✓ MD]
FR / [✓ MD]
[✓ EF] / MD

[✓ TD] / PD
[✓ OP] / PD
[✓ FR] / PD
[✓ EF] / PD
[✓ TD] / OP

[✓ TD] / FR
[✓ TD] / EF
OP / [✓ FR]
OP / [✓ EF]
EF / [✓ FR]

TALLY OF IMPORTANCE SELECTIONS

MD III = 3
PD = 0
TD IIIII = 5
OP I = 1
FR III = 3
EF III = 3
SUM = 15

RATING SCALES:

INSTRUCTIONS: PLACE A MARK ON EACH SCALE THAT REPRESENTS THE MAGNITUDE OF EACH FACTOR IN THE TASK YOU JUST PERFORMED

DEMANDS	RATINGS FOR TASK 1:			RATING		WEIGHT		PRODUCT
MD	LOW	I ___x___________ I	HIGH	30	x	3	=	90
PD	LOW	I _x_____________ I	HIGH	15	x	0	=	0
TD	LOW	I __________x____ I	HIGH	60	x	5	=	150
OP	EXCL	I _____x_________ I	POOR	40	x	1	=	40
FR	LOW	I ___x___________ I	HIGH	30	x	3	=	90
EF	LOW	I _____x_________ I	HIGH	40	x	3	=	120
				SUM			=	490
				WEIGHTS (TOTAL)			=	15
				MEAN WWL SCORE			=	32

DEMANDS	RATINGS FOR TASK 2:			RATING		WEIGHT		PRODUCT
MD	LOW	I ___x___________ I	HIGH	30	x	3	=	90
PD	LOW	I __x____________ I	HIGH	25	x	0	=	0
TD	LOW	I ____________x__ I	HIGH	70	x	5	=	350
OP	EXCL	I ______x________ I	POOR	50	x	1	=	50
FR	LOW	I ______x________ I	HIGH	50	x	3	=	150
EF	LOW	I __x____________ I	HIGH	30	x	3	=	90
				SUM			=	730
				WEIGHTS (TOTAL)			=	15
				MEAN WWL SCORE			=	49

RESULTS:

SUBSCALES PINPOINT SPECIFIC SOURCE OF WORKLOAD VARIATION BETWEEN TASKS (TD). THE WWL SCORE REFLECTS THE IMPORTANCE OF THIS AND OTHER FACTORS AS WORKLOAD-DRIVERS AND THEIR SUBJECTIVE MAGNITUDE IN EACH TASK

Figure 4.5 Example of the Nasa TLX (Hart & Staveland, 1988)

4.6.1.3 Individual Stress

Individual stress refers to the extent to which an individual responds psychologically or physiologically to a perceived misfit between resource availability for current task performance and environmental resource demand (Caplan et al., 1975; Lazarus, 1966; 1999). Stress was captured objectively through salivary stress hormones and subjectively through a stress scale.

Consistent with prior research in the domain of T-M interruptions (Galluch, 2009), this dissertation used alpha-amylase (sAA), a salivary stress hormone, as an objective measure of individual stress. While such other objective measures of stress as cortisol are also common in studies on individual well-being (e.g., Lopata et al., 2008; Weems et al., 2008; Weigensberg et al., 2009), sAA has been shown to vary more on the basis of temporary technostress than does cortisol (Galluch, 2009). To capture sAA from the participants, we used salivettes, which have been shown to be an appropriate tool for this purpose (Rohleder et al., 2006)

The measure was administered by instructing participants to open a tube and insert a cotton-like oral swab into their mouths for two minutes (Salimetrics, LLC, 2009; Neupert et al., 2006). Oral swabs are particularly easy to use and, hence, of little intrusiveness as compared to, for example, requiring participants to drool saliva into a vial (Salimetrics, LLC, 2009). Subjects were instructed to put the tube up to their mouth and place the swab between cheek and gum (i.e., near the upper 2nd molar), while tilting their head slightly and not touching the swab with their hands (Galluch, 2009; Salimetrics, LLC, 2009). After two minutes, subjects removed the swab from their mouth by putting the empty tube up to their mouth and rolling the swab out with their tongue (Galluch, 2009). Following this procedure, the participants closed the tube and handed it over to the facilitator, who stored it in a zip-lock bag (Salimetrics, LLC, 2009). Once salivary measures were obtained, the tubes were labeled, frozen immediately at minus 20 degrees Celsius, and subsequently shipped in dry ice through Federal Express to the Salimetrics assay firm for analysis (Galluch, 2009; Salimetrics, LLC, 2009).

In line with calls for methodological triangulation in IS research, we additionally administered a perceptual stress scale, which was adapted from the five-item work exhaustion subscale of the General Burnout Questionnaire (Schaufeli et al., 1995). This scale has been used successfully in prior research. Moore (2000) employed the instrument in her seminal work in the context of stress in IT professionals, and Galluch (2009) used it in the domain of T-M interruptions. Table 4.7 presents our perceptual measure of individual stress[12].

Item #	Item
IS1	I felt emotionally drained from working on the memory task.
IS2	I felt used up due to the task demands.
IS3	I felt fatigued due to the task demands.
IS4	I felt burned out from working on the memory task.
IS5	I felt strain due to the task demands.
Scale Range: 1 = Strongly Disagree; 4 = Neutral; 7 = Strongly Agree	
Stem: For each of the statements below, please indicate your level of stress experienced in consequence of working on the memory task by selecting the appropriate response.	

Table 4.7 Items for Individual Stress

4.6.1.4 Task Performance

Task performance refers to the extent to which individual task output is effective in meeting task objectives (Burton-Jones, 2009; Burton-Jones & Straub, 2006). In the Concentration task, performance is generally measured as the number of trials or moves

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[12] This measure could be considered a measure of strain rather than stress. To identify an appropriate label, we examined the extant literature but found that past research has labeled stress in inconsistent ways. For example, some (e.g., Galluch, 2009) referred to stress perceptions as stress and to the physiological manifestations of these stress perceptions as strain. Others (e.g., Chang et al., 2009; Lang et al., 2007) referred to stress perceptions as psychological strain and to physiological experiences of stress as physiological or physical strain. Given this inconsistency in the terminology used in the extant literature, we decided to label experiences of stress, whether psychological or physiological, as individual stress. We believe that this label offers a simple and useful way to denote experiences of stress or strain.

required to find all matching pairs (e.g., Baker-Ward & Ornstein, 1988; Eskritt et al., 2001; Schumann-Hengsteler, 1996). This performance measure had to be adapted to fit the context of this study. Since the subjects had to experience time pressure, we measured performance as the number of matching pairs uncovered within a given time period. Due to varying experiences of stress, it was expected that not all subjects would uncover the same number of matching pairs.

4.6.2 MEASURES PERTAINING TO AGE-RELATED MANIFESTATIONS

In the following subsections we discuss the age ranges pertaining to younger and older individuals, 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 for the salience of T-M interruptions.

4.6.2.1 Adult Age

Within the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988), age effects have consistently been measured by comparing chronologically younger to older individuals (Hasher et al., 1991; Hasher & Zacks, 1988; Zacks & Hasher, 1997). Averages computed across all studies conducted by Hasher, Zacks, and colleagues between 1990 and 2007 revealed that undergraduate students between 18 and 23 years of age with a mean age of 20 are commonly used to represent younger people, while independently-living community-dwelling adults between 61 and 77 years of age with a mean age of 69 are commonly used to represent older people. However, several studies include participants of up to 26 years of age in their sample of younger adults (e.g., Radvansky et al., 1990; 1996; Zacks et al., 1996) and individuals up to 82 years of age in their sample of older adults (e.g., Radvansky et al., 1990; 1996; Zacks et al., 1996). Based on these studies, we defined as younger adults those between 18 and 26 years of age, and as older those between 60 and 85 years of age.

4.6.2.2 Inhibitory Effectiveness

Inhibitory Effectiveness refers to the extent to which an individual can deliberately inhibit or down-regulate the processing of distracting information, thereby preventing distractors from gaining access to mental resources (Hasher & Zacks, 1988; Zacks & Hasher, 1997). The construct is often evaluated using the STROOP color-word test (Stroop, 1935), which is the most widely accepted test for inhibition since it most accurately maps onto the definition of the concept (Shilling et al., 2002). The Stroop task requires subjects to ignore attentionally compelling but unwanted signals and to suppress responses to these signals while working on a primary task. This procedure directly tests a subject's ability to inhibit an irrelevant or intrusive channel of information by presenting color names printed in non-consistent ink colors. Individuals must actively inhibit the printed names of colors, while selectively attending to the ink color in which the words are printed.

To illustrate the Stroop task, a subject may have to name the ink color green for a word that reads "blue." Since most people have a natural and strong tendency to read, they must inhibit this response to be able to correctly name the ink color (Shilling et al., 2002). The test yields the STROOP effect, which is the difference between response times with incongruent and congruent words. This mean difference score is consistently found to be higher for older adults. Figure 4.6 illustrates this test, which essentially involves conflict between competing responses and takes approximately five minutes to be completed. Since color is a major aspect of this test, we asked our participants whether they were color blind.

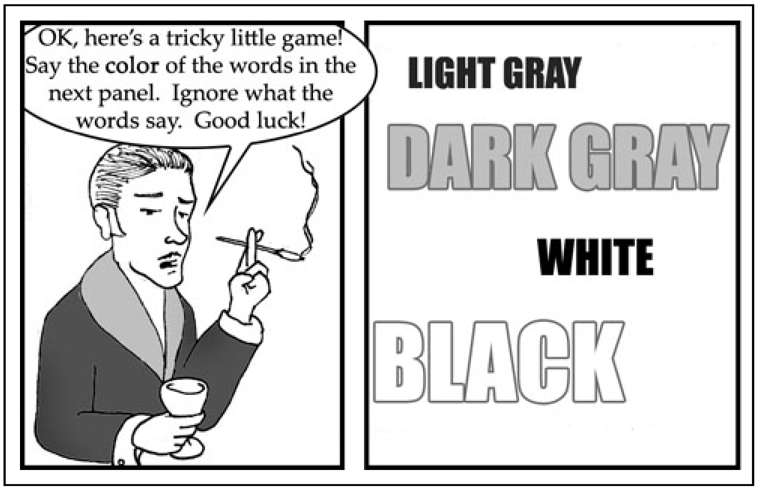


Figure 4.6 The STROOP color-word task

4.6.2.3 Computer Experience

Computer experience refers to the extent to which individuals have been using computers over their lifetimes (Harrison & Rainer, 1992; Taylor & Todd, 1995). The construct has been measured in a variety of ways. In IS research, it has been evaluated as the number of “years of hands-on computer-use” (Harrison & Rainer, 1992; p. 103) and as a binary variable equaling one in case of prior experience with a particular system and zero otherwise (Taylor & Todd, 1995). Outside the IS field, computer experience has been measured more comprehensively. Potosky and Bobko (1998) developed the

Computer Understanding and Experience Scale (CUE), which is a 12-item measure of computer experience. Since its development, this instrument has been successfully used by other studies (e.g., Beckers & Schmidt, 2003; Potosky & Bobko, 2001) and has been shown to have sufficient internal consistency reliability with a coefficient alpha of .78 (Potosky & Bobko, 2001). The CUE captures individual "know how" with respect to two domains: technical and general computer competence. It includes the following items (Potosky & Bobko, 1998, p. 342):

- "I frequently read computer magazines or other sources of information that describe new computer technology.
- I know how to recover deleted or "lost data" on a computer.
- I know what a LAN is.
- I know what an operating system is.
- I know how to write computer programs.
- I know how to install software on a computer.
- I know what e-mail is.
- I know what a database is.
- I am computer literate.
- I regularly use a PC for word processing.
- I often use a mainframe computer system.
- I am good at using computers."

While the first six items relate to technical computer competence, the latter six capture general computer competence. The scale's strength is its comprehensiveness. Yet, its items may not yield much variance. To illustrate, people can be expected to either know or not know what a LAN is. There will not be much variance between "knowing" and “not knowing.” Likewise, most people will know what e-mail is, although they may use it to different extents. Hence, a better item may ask respondents to indicate the extent to which they rely on email for their communication, rather than simply requiring a response as to whether people know what e-mail is. As a result of such adjustments, the items may yield more variance. In addition, the CUE contains items that may not fit contemporary computing environments. For example, installing software on a computer today seldom requires specialized knowledge since software installations occur predominantly automatically. Furthermore, such items as “I am computer literate” and “I am good at using computers” may capture more than plain experience; they may confound experience with confidence.

The instrument developed by Bozionelos (2004) accounts for these problems to some extent. His 10-item scale for computer experience relates to the frequency of use of a wide range of computer products, such as software, hardware, and networking products. The items range from such common applications as word-processing software use and internet browser use to more advanced ones like programming language use. More specifically, the scale includes the following items (pp. 742-743):

> “Please indicate your level of experience in working with computers by choosing one of the numbers on the five-point scales provided (1: never; 2: once or twice; 3: occasionally; 4: often; 5: regularly):
>
> - Using a word-processing package on a computer.
> - Using computer packages such as spreadsheets or data management software.
> - Use of a programming language such as BASIC, PASCAL, C, C++, etc.

- Use of operating systems such as MS DOS, MS Windows, Mac O/S, Unix, Linux, etc.
- Use of groupware systems such as Lotus Notes and MS Exchange.
- Use of Internet browsers such as Netscape, AOL, Internet Explorer and HotJava.
- Use of Internet-oriented languages such as Java, JavaScript, Perl, Flash, Html.
- Use of CD ROM or on-line resources such as Psych-lit, ABI, Extel, etc.
- Use of external hardware devices such as Scanners, Plotters, Audio–visual peripherals.
- Installation of software (e.g. statistical packages, spreadsheets, etc.) and hardware (e.g. Mouse, Printer, Hard-disk, RAM, etc.)”

While Bozionelos’ (2004) instrument seems to capture more variance and to include fewer confounding items than the CUE, its applicability is still limited. For example, few individuals still rely on MS DOS, and older people have limited reasons for using programming languages. Further, the instrument lacks an overall assessment item, such as Harrison and Rainer’s (1992) “years of hands-on computer-use.” Hence, we adopted only some of Bozionelos’ (2004) ideas and augmented them with an overall assessment item. We focused our measure on internet use since the use of the internet is highly relevant for both younger and older people (White et al., 2002). To ensure item objectivity, subjects rated their frequencies of use in terms of specific time intervals ranging from less than once a year to about every day (Igbaria et al., 1995; Smith et al., 2000) (see Table 4.8). In addition, by carefully applying the guidelines advanced by Smith et al. (1999; 2007) and Churchill (1979), we constructed a measure for memory game Concentration experience (see Table 4.9).

Item #	Item
GCE1	On average, how frequently do you use a computer for communicating with others (e.g., through e-mail, instant messages, Facebook)
GCE2	On average, how frequently do you use Internet browsers such as FireFox, Internet Explorer and Google Chrome?
GCE3	Overall, how frequently do you use a computer?
Scale Range: 1 = Once a year or less; 3 = Several times a month; 5 = Every day or about every day	
Stem for items 1-7: For each of the statements below, please indicate your level of experience in working with computers by selecting the appropriate response.	

Table 4.8 Items for Computer Experience

Item #	Item
SCE1	I have frequently played the memory game Concentration
SCE2	I have played the memory game Concentration a lot.
SCE3	I have often played the memory game Concentration.
SCE4	I have experience with the memory game Concentration.
SCE5	On average, how frequently have you played the memory game Concentration?
Scale Range: 1 = Strongly Disagree; 4 = Neutral; 7 = Strongly Agree	
Stem: For each of the statements below, please indicate your level of experience by selecting the appropriate response.	

Table 4.9 Items for Memory Game Concentration Experience

4.6.2.4 Computer Self-Efficacy

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 adopted items for general CSE from Compeau and Higgins (1995). Their original 10-item measure, which has regularly been used in IS research and consistently been shown to have good construct validity and reliability, is provided in Table 4.10. In addition, by carefully applying the guidelines advanced by Marakas et al. (1998; 2007) and Churchill (1979), we constructed a measure for memory game Concentration self efficacy (see Table 4.11).

Item #	Item
GCSE1	...if there was no one around to tell me what to do as I go.
GCSE2	...if I had never used a package like it before.
GCSE3	...if I had only the software manuals for reference
GCSE4	...if I had seen someone else using it before trying it myself.
GCSE5	...if I could call someone for help if I got stuck.
GCSE6	...if someone else had helped me get started.
GCSE7	...if I had a lot Of time to complete the job for which the software was provided.
GCSE8	...if I had just the built-in help facility for assistance.
GCSE9	...if someone showed me how to do it first.
GCSE10	...if I had used similar packages before this one to do the same job.
Scale Range: 1 = Not at all confident; 4 = Moderately confident; 7 = Totally Confident Stem: I could complete a job using the computer ...	

Table 4.10 Items for General Computer Self-Efficacy

Item #	Item
SCSE1	…describe how to play the memory game Concentration.
SCSE2	…excel in the memory game Concentration.
SCSE3	…be successful at the memory game Concentration.
SCSE4	…perform well in the memory game Concentration.
Scale Range: 1 = Not at all confident; 4 = Moderately confident; 7 = Totally Confident	
Stem: I believe I have the ability to …	

Table 4.11 Items for Memory Game Concentration Self-Efficacy

4.6.2.5 The Salience of T-M Interruptions

The salience of T-M interruptions refers to the extent to which T-M interruptions are salient in terms of their color, dynamism, and aural features (Houghton & Tipper, 1994; Strayer & Drews, 2007; Wickens et al., 2004). Contemporary T-M interruptions often combine features aimed at involuntarily capturing individual attention (Strayer & Drews, 2007). For example, in the current version (i.e., 4.2.0.169) of Skype, instant messages appear coupled with flashing and an aural alert in a reddish color (orange). In so doing, they combine color, dynamism, and aural features to appeal to individuals' attentional amplification mechanism, thereby capturing attention.

Color code refers to the color in which T-M interruptions appear in a display. Because of peoples' past experiences with such human-designed systems as traffic lights and dashboards (Wickens et al., 2004), research consistently finds red to be the most salient color, followed by orange, yellow, and green (e.g., Bayot et al., 2008; Luoma et al., 1997; Wickens et al., 2004). This coding scheme for color is consistent with the codes used by the American Aviation Community (Wickens et al., 2004) and the U.S. Department of Homeland Security (Rivera et al., 2006). Since red as opposed to green has historically been associated with importance in human-designed systems, the distinction between red and green is particularly salient (Wickens et al., 2004). Dynamism refers to the extent to which appearing objects are emphasized through flashing (Yantis & Jonides, 1990; Yantis, 1993b) or stimuli movement (McLeod et al., 1991; Franconeri & Simons, 2003) as opposed to static. For example, internet pop-up advertisements often move across the screen rather than being static display elements. Auditory alert refers to the extent to which T-M interruptions are accompanied by a sound when they appear on the screen. Since aural alerts are highly salient (Strayer & Drews, 2007), such T-M interruptions as instant messages that appear together with a sound may be likely to capture attention. This even holds true for continuously presented and hence expected irrelevant sounds and when subjects are being explicitly instructed to ignore distracting sounds (Berti et al., 2004; Jones et al., 1999).

In line with the literature on selective attention (e.g. Sagarin et al., 2003), we manipulated the salience of T-M interruptions through two levels: lower and higher. Using these two manipulations allowed us to clearly delineate the moderating impact of interruption salience without unreasonably inflating the research design. Since the relationship between feature salience and attentional capture is not considered to be curvilinear (Yantis & Egeth, 1999), using a middle group for salience would not have enhanced our understanding of its interaction with the frequency of T-M interruptions.

Because of the ubiquity of feature combinations in modern computing environments (Strayer & Drews, 2007), the higher level manipulation of salience could have included interruptions appearing with movement and an aural alert in a reddish color (red). By contrast, the lower level manipulation could have included interruptions appearing without movement and without an aural alert in a green color. However, such an aggregate measure may have obscured the workload implications of the salience of T-M interruptions. For instance, color code may generally be highly pertinent, while aural alerts may generally be of little relevance to the workload implications of T-M interruptions. When evaluated as a monolith, the salience of T-M interruptions may appear to have little influence on the effect of the frequency of T-M interruptions on mental workload perceptions, when perhaps different facets of salience have conflicting implications.

The question arose of which facet of salience should be used for this research. Since aural alerts may have confounded salience with hearing abilities and since interruption movement may have been too salient and may have resulted in little variance in workload perceptions, we used color codes to operationalize salience. Specifically, we used a red border around the interruptions (see Figure 4.7 left) as a manipulation of higher salience since past research has consistently found red to be the most salient color (e.g., Bayot et al., 2008; Luoma et al., 1997; Wickens et al., 2004). Also consistent with prior research we employed a gray border around the interruptions (see Figure 4.7 right) as a manipulation of lower salience (Wickens et al., 2004). Table 4.12 presents the perceptual manipulation check of the salience manipulation.

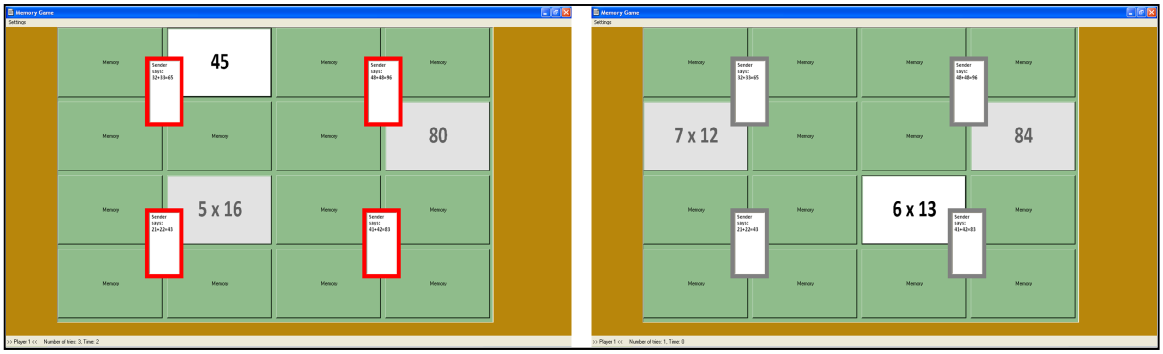


Figure 4.7 Higher (left) and Lower (right) Salience Manipulations

Item #	Item
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.
Scale Range: 1 = Strongly Disagree; 4 = Neutral; 7 = Strongly Agree	
Stem: Please indicate the extent to which you agree or disagree with the following statements describing the salience of the interruptions that appeared during the memory task you just did:	

Table 4.12 Items for the Salience of T-M Interruptions

4.6.3 CONTROL VARIABLES

The experimental room was organized to control for extraneous distractions. All work tables faced walls and all jalousies were closed. The experimenter sat quietly. We further controlled for alternative explanations pertaining to perceived mental workload, individual stress, and task performance. Concerning mental workload perceptions, we controlled based on prior research for working memory capacity, short-term memory, age, and experience with as well as confidence regarding the memory game Concentration (Hart & Staveland, 1988; Sharit et al., 1998; Wierwille & Eggemeier, 1993; Yeh & Wickens, 1988).

Individual working memory capacity was evaluated using the computation span test (Salthouse & Babcock, 1991). Entirely consistent with the Concentration task, this test requires the subjects to select the correct answer to an arithmetic problem while simultaneously remembering words. As such, the task requires both storage and processing of information and, hence, fully accounts for differences in individual working memory. More specifically, after the presentation of each arithmetic problem, the participants choose the correct answer from a list of alternatives. After each arithmetic problem the participants are presented with a word. Once the designated number of arithmetic problems has been completed, the participants have to recall the words in order. The participants were further instructed that answering the math problems correctly has top priority, and that the recall of words will only be relevant if the processing task was performed correctly (Salthouse & Babcock, 1991). Short-term memory was measured using the digit symbol substitution task, which requires people to remember symbols that correspond to the numbers one through nine over a 90 seconds period (McLeod et al., 1982). Age was measured chronologically, and memory game Concentration experience and self-efficacy were measured using the scales introduced earlier (i.e., in sections 4.4.2.3 and 4.4.2.4).

Concerning individual stress, we controlled consistent with prior research for gender, education, age, and physical activity (e.g., Norris et al., 1992; Ragu-Nathan et al., 2008; Unger et al., 1997; Wang et al., 2008). Gender was recorded as “male” or “female” and education was measured on an 8-point scale: “1” for no formal education, “2” for less than high school graduate, “3” for high school graduate/GED, “4” for vocational training, “5” for some college/associate’s degree, “6” for college graduate, “7” for master's degree (or other post-graduate training), and “8” for a doctoral degree (PhD, MD, EdD, DDS, JD, etc). Age was measured chronologically, and physical activity was measured on a single item ranging from “every day” to “once a year or less” (Wilson et al., 1999): “How often do you typically engage in physical activities such as running, swimming, jogging, or other types of sports?” (Newson & Kemps, 2006). Additionally, a number of factors had to be considered so as not to contaminate the sAA measure (Salimetrics, LLC, 2009). Prior to their participation, we instructed the subjects to avoid alcohol for 12 hours before sample collection, not to have a major meal within 1 hour of sample collection, to avoid dairy consumption for 20 minutes before sample collection, and to avoid the consumption of caffeine immediately before sample collection (Klein et al., 2010; Salimetrics, LLC, 2009). In addition to instructing the subjects to avoid these potential contaminates, we documented participants’ consumption of them (Salimetrics, LLC, 2009).

Concerning task performance, we controlled based on prior research for participants' math accuracy scores on an arithmetic test, mental activity, gender, and education (Baker-Ward & Ornstein, 1988; Schumann-Hengsteler, 1996; Washburn et al., 2007). The math accuracy scores were obtained from on operation span task, which required the participants to solve a series of arithmetic problems. Mental activity was measured on a single item ranging from "every day" to "once a year or less" (Wilson et al., 1999): "How often do you typically engage in mental activities such as reading, learning, or playing mentally demanding games (e.g., crossword puzzles, checkers, Sudoku, chess, etc.)?" (Newson & Kemps, 2006; Wilson et al., 1999). The remaining variables were measured as noted before.

While all of the above factors were explicitly controlled for, age-related differences in task performance were implicitly controlled. More specifically, since older individuals tend to suffer from declining motor functions, they tend to incur longer pointing times when using the computer mouse as a pointing device, particularly for complex mouse control tasks such as double-clicking operations (Charness et al., 2004; Murata, 2006; Smith et al., 1999). While this aspect may not have been a particular concern in our study, where, due to voluntary participation, all participants had experience in using the mouse, we nonetheless implicitly controlled for it though a number of strategies. First, we adjusted the interface in terms of accelerating functions to optimize movement control of the mouse. Research has shown that interface adjustments in terms of acceleration profiles minimize age-related differences in accurately using the mouse as a pointing device (Walker et al., 1997). Second, since the double-clicking operation is the most difficult mouse control task and the most sensitive one to age-related differences (Smith et al., 1999), the participants performed all tasks using single clicks only (Charness et al., 2004; Murata & Iwase, 2005).

Finally, we used cards of large size (i.e., at least 156 x 156 pixels) in the Concentration task to ease the pointing movement. Large cards also allowed us to implicitly control for differences in vision. We further controlled for vision by having the subjects indicate whether they owned prescription glasses or contact lenses and whether they were using them at test time. Figure 4.8 shows how these control variables map onto our research model, and Table 4.13 summarizes these control variables.

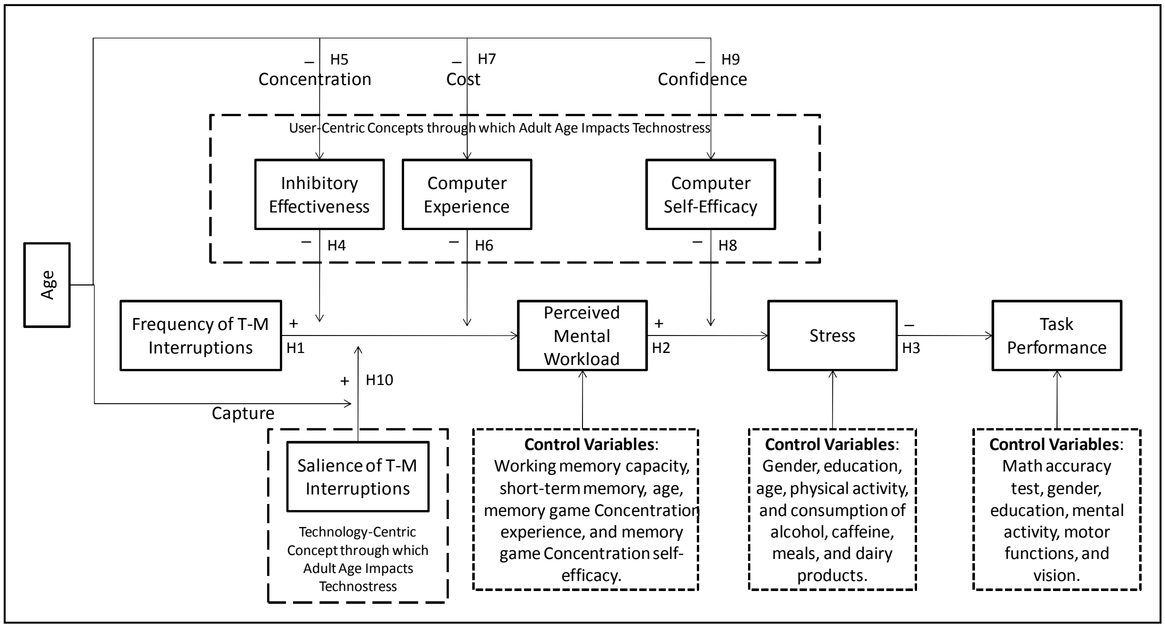


Figure 4.8 Research Model Augmented with Control Variables

Category	Control Variable	Definition	Measure	Reference
Contextual	Location	Room in which the experiment was conducted	Research Laboratory 410k in Bracket Hall, Clemson University	n/a
	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 quitly at all times	n/a
	Time	Time of day at which the experiment was conducted	At 10am and 2pm	n/a
Mental Workload	Working Memort 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 seconds period	McLeod et al., 1982
	Age	Chronological age	Measured chronologically as a continuous variable	Yeh & Wickens 1988; Sharit et al 1998
	Concentration experience	Extent to which an individual has been playing Concentration over her lifetime	Five-item measure introduced in section 4.5.2.3	Smith et al. (1999; 2007); Wierwille & Eggemeier, 1993
	Concentration self-efficacy	Extent to which an individual beliefs in her ability to successfully play Concentration	Four-item measure introduced in section 4.5.2.4	Smith et al. (1999; 2007); 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
	Age	Chronological age	Measured chronologically as a continuous variable	Yeh & Wickens 1988; Sharit et al 1998
	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
	Alcohol consumption	Whether an individual has consumed alcohol 12 hours before the experiment	Binary variable equal to 0 if no alcohol was consumed and 1 otherwise	Salimetrics LLc.
	Food consumption	Whether an individual has consumed a major meal 1 hour before the experiment	Binary variable equal to 0 if no major meal was consumed and 1 otherwise	Salimetrics LLc.
	Dairy consumption	Whether an individual has consumed dairy products 20 minutes before the experiment	Binary variable equal to 0 if no dairies were consumed and 1 otherwise	Salimetrics LLc.
	Caffeine consumption	Whether an individual has consumed caffeine immediately before the experiment	Binary variable equal to 0 if no caffeine was consumed and 1 otherwise	Salimetrics LLc.
Task Performance	Math Accuracy	Extent to which an individual can accurately solve arithmetic problems	Operation Span task	Salthouse & Babcock, 1991
	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
	Motor functions	Differences in operational accuracy between computer mouse users	Prior experience using the mouse, no double-clicling operations	Charness et al., 2004; Smith et al., 1999
	Vision	Differences in vision between participants	Using playing cards of large size and having subjects indicate whether they owned prescription glasses and were wearing them at test time	Czaja et al., 2006

Table 4.13 Summary of Control Variables

4.7 PRE- AND PILOT TESTING

We conducted multiple pre- and pilot tests before the full-scale experiment was deployed. We began with the pretest, which was largely exploratory, to calibrate our measures, manipulations, and procedures. We planned for at least 12 younger and 8 older adults, who would participate in the pretests. In an attempt to gain a better understanding of the pretest participants' thought processes about the usefulness of our experimental materials, we asked the subjects to provide a verbal protocol in addition to quantitative information. Following each pretest, we interviewed all participants regarding their overall opinion of the materials as well as procedure and regarding potential inconsistencies in their responses.

Following the initial calibration of our materials and procedures, we conducted a pilot-test, which simulated the full-scale experiment. As such, the pilot required the participants to sign the approved Informed Consent Letter. To ensure a proper simulation, we ascertained that the subjects believed they were participating in the full-scale experiment. Pilot-testing generally serves two important objectives: testing the experimental materials and providing a preliminary evaluation of the research model (Dennis & Valacich, 2001). First, we used the pilot to test whether the experimental manipulations, measures, and procedures operated as intended. This involved testing for the reliability and validity of the construct measurements as well as obtaining feedback on unclear aspects of the experimental procedure. Further, although we designed the procedure on the basis of careful estimates of the time needed for each activity, the pilot helped us establish the final estimate of the total time required to complete the entire procedure (Lim & Benbasat, 2002), from subject briefing to debriefing.

Second, the pilot was used to derive a preliminary evaluation of the theory. Although the sample size of pilots does generally not allow for formal hypotheses testing, it should provide an idea of the direction of the means. In so doing, a pilot can generally lend support to a research model by indicating whether the means are in the same direction as the model suggests. In case the means are not in the expected direction, the research design may have to be altered. To evaluate a research model in this way, two or three data points should be collected per each experimental condition (Dennis & Valacich, 2001). This general rule renders a sample size of 12 subjects in a repeated measures design sufficient for our pilot test. Due to the difficulty inherent in recruiting older subjects for pilot testing, we aimed for 60% younger and 40% older people. The results from the pre- and pilot-tests are presented in the next chapter.

4.8 CHAPTER SUMMARY

We designed a laboratory experiment for testing our research model by detailing who the experimental subjects were and what privileges they had, what task was used, how the laboratory experiment itself was designed, was procedure was employed, and how we measured and manipulated the theoretical constructs in our research model.

Students were used as representatives of younger adults, while community-dwelling older workers and retirees represented older adults. We incentivized participation through monetary compensation and the drawing of a number of valuable prices. To motivate high task performance above and beyond the engaging nature of the experimental task, we told the participants that (1) the drawing of the prices depended on their performance in the Concentration task so that higher performance yielded a greater likelihood to win a price and (2) we would compile a performance ranking on the basis of counterfeit names that would be sent to all participants upon completion of the study.

Concerning the experimental task, we indicated that the computerized memory game Concentration was useful to test our research model since it bridged age groups, offered tremendous flexibility in calibrating the demands on working memory, and required the participants to sustain their attention. Further, the task was simple, engaging, and motivated high performance, implying that a lack of understanding of the task or a lack of motivation was unlikely to bias our results. Each participant evaluated two experimental conditions.

We designed a mixed-model full-factorial experiment. Two Between factors and one Within factor with two levels each were used in an experiment that evaluated all resulting eight conditions, allowing us to test for the three-way interaction among adult age, the frequency of T-M interruptions, and the salience of T-M interruptions. The participants were assigned at random to the experimental conditions, and sAA measures were taken before and after each condition, increasing the internal validity of the study. As indicated by the power analysis, 125 participants had to be recruited for the experiment when anticipating up to 40% of the data to be unusable. After the full-scale experiment was conducted, repeated measures ANOVA was used to test the hypotheses. We present these analyses and the results obtained from them in the next chapter.

Chapter Five: Results

5.1 INTRODUCTION

This chapter reports the results from the experiment. It begins with a description of the instrument development process, followed by a description of the research sample. Next the chapter discusses the quality criteria and descriptive statistics of our study variables and manipulations. Finally, it reports on the results from the hypotheses testing.

To test our hypotheses, Repeated Measure Analysis of Variance (RM-ANOVA) was used 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). Repeated Measure ANOVA is an ANOVA extension that accounts for time as a third dimension of data; it takes into account that all participants generate scores under two or more different experimental conditions (Cohen et al., 2003). In RM-ANOVA, variance components for three-dimensional data structures are used such that they produce appropriate standard errors (RM-ANOVA separates variation into within subjects and between subjects components) where simple ANOVA would produce misestimated standard errors since it assumes an only two-dimensional data structure (Cohen et al., 2003). Design-wise, Repeated Measure ANOVA is efficient in that it requires fewer participants than simple ANOVA, minimizing resource wastage and allowing for faster study completion times. In addition to RM-ANOVA, we used ordinary least squares regression analysis and independent sample t-tests where appropriate.

The experiment was executed using a detailed experimental protocol to ensure consistent treatment of all participants. Further, the investigator always adhered to the same dress code and small talk topics to further ensure consistency and precision.

5.2 EXPERIMENTAL MATERIALS AND SURVEY INSTRUMENT

Below we describe the development of the task and manipulations as well as of the survey instrument used in this study. We begin by detailing the development and pre-testing of our experimental task and manipulations. Then, we discuss the development process and pre-testing of the survey instrument, which accompanied the experimental task. We then report on the results from a pilot study and discuss the changes made to the research instrument in response to the pilot. Finally, we describe our findings from a preliminary analysis of the first data collected and conclude with the changes made.

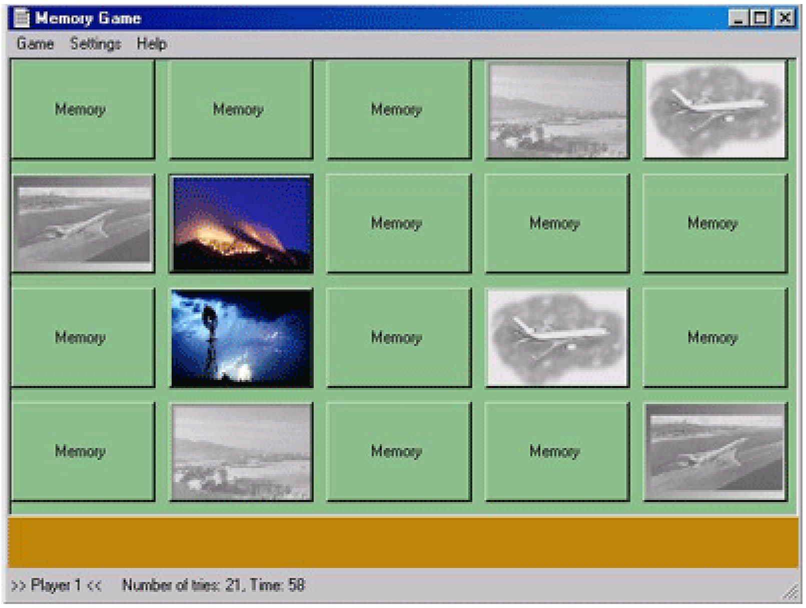
5.2.1 EXPERIMENTAL TASK AND MANIPULATIONS

Below, we first describe how the initial version of the experimental task was developed. Following this, we describe the pre-tests undertaken to calibrate, adjust, and evaluate the experimental task and manipulations.

5.2.1.1 Development of the Experimental Task and Manipulations

To develop the experimental task in form of the memory game Concentration, a highly qualified computer programmer with a background in Information Systems research was hired. He downloaded a freeware version of Concentration from the internet (“Memory Game version 1.0 R2” by Raimund Neumueller, http://www.c-sharpcorner.

com/UploadFile/raimundneumuller/MemoryGame11292005034412AM/MemoryGame.aspx) and modified this version to fit the study context (see Figures 5.1 and 5.2). The resulting software allowed the researcher to freely vary such parameters as game duration, the time interval at which interruptions appear, and the number of simultaneously appearing interruptions.



>> Player 1 <<   Number of tries: 21, Time: 58

Figure 5.1 Freeware Version of Concentration Before Modification

Sender says: 32+33=65

Sender says: 48+48=96

Sender says: 21+22=43

Sender says: 41+42=83

>> Player 1 << Number of tries: 3, Time: 2

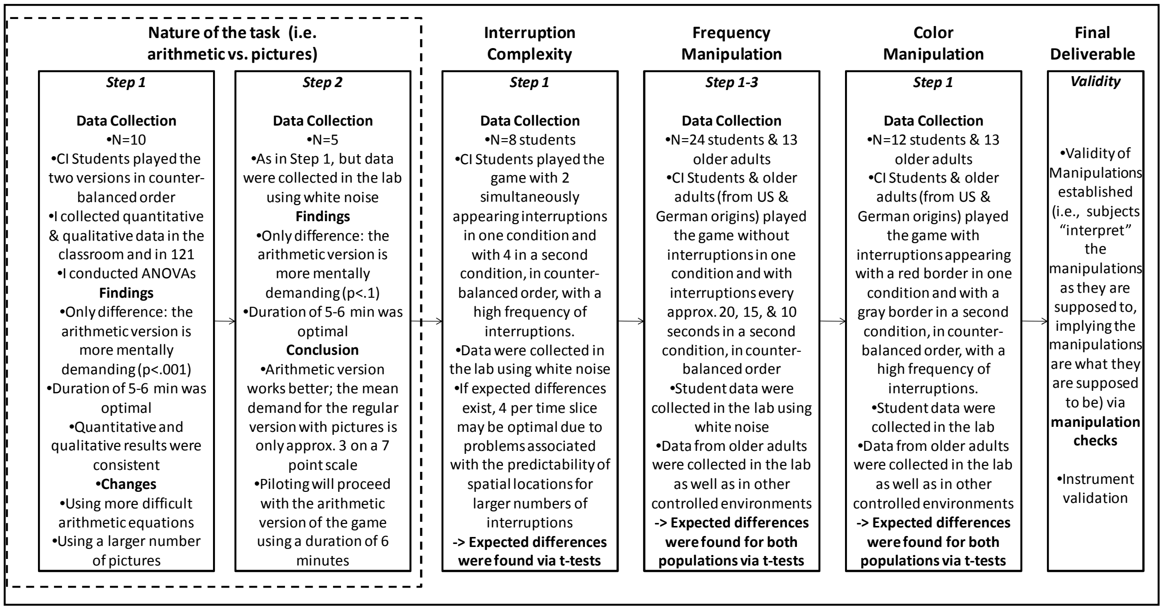
Figure 5.2 Freeware Version of Concentration After Modification

5.2.1.2 Pre-Testing of the Experimental Task and Manipulations

The Concentration task was extensively pre-tested in order to calibrate, adjust, and evaluate the manipulations (see Figure 5.3). More specifically, the pre-test of the experimental task and manipulations had four objectives:

1. Identification of whether the traditional version of the Concentration task with pictures or the arithmetic version outlined in the preceding chapter had higher validity for this research.
2. Identification of what level of interruption complexity (i.e., the number of simultaneously appearing interruptions) constituted a valid stimulus for attentional inhibition.
3. Identification of valid manipulations for interruption frequency and salience such that a particular instance of a manipulation (e.g., a frequency of 10 seconds) could be considered significantly higher or lower than another instance (e.g., a frequency of 90 seconds).
4. Initial evaluation of the experimental procedure and protocol.

Consistent with recent experimental IS research (e.g., Qiu & Benbasat, 2009), we used the significant difference method to determine whether a manipulation was valid. More specifically, when two instances of a manipulation (e.g., lower and higher frequency) were perceived as significantly different by the pre-test participants, we concluded that a valid manipulation was found, with the relatively lower frequency (e.g., 90 seconds) constituting the "lower" manipulation and the relatively higher frequency (e.g., 15 seconds) constituting the "higher" manipulation.


Nature of the task (i.e. arithmetic vs. pictures)

Step 1

Data Collection
•N=10
•CI Students played the two versions in counter-balanced order
•I collected quantitative & qualitative data in the classroom and in 121
•I conducted ANOVAs
Findings
•Only difference: the arithmetic version is more mentally demanding (p<.001)
•Duration of 5-6 min was optimal
•Quantitative and qualitative results were consistent
•Changes
•Using more difficult arithmetic equations
•Using a larger number of pictures

Step 2

Data Collection
•N=5
•As in Step 1, but data were collected in the lab using white noise
Findings
•Only difference: the arithmetic version is more mentally demanding (p<.1)
•Duration of 5-6 min was optimal
Conclusion
•Arithmetic version works better; the mean demand for the regular version with pictures is only approx. 3 on a 7 point scale
•Piloting will proceed with the arithmetic version of the game using a duration of 6 minutes

Interruption Complexity

Step 1

Data Collection
•N=8 students
•CI Students played the game with 2 simultaneously appearing interruptions in one condition and with 4 in a second condition, in counter-balanced order, with a high frequency of interruptions.
•Data were collected in the lab using white noise
•If expected differences exist, 4 per time slice may be optimal due to problems associated with the predictability of spatial locations for larger numbers of interruptions
-> Expected differences were found via t-tests

Frequency Manipulation

Step 1-3

Data Collection
•N=24 students & 13 older adults
•CI Students & older adults (from US & German origins) played the game without interruptions in one condition and with interruptions every approx. 20, 15, & 10 seconds in a second condition, in counter-balanced order
•Student data were collected in the lab using white noise
•Data from older adults were collected in the lab as well as in other controlled environments
-> Expected differences were found for both populations via t-tests

Color Manipulation

Step 1

Data Collection
•N=12 students & 13 older adults
•CI Students & older adults (from US & German origins) played the game with interruptions appearing with a red border in one condition and with a gray border in a second condition, in counter-balanced order, with a high frequency of interruptions.
•Student data were collected in the lab
•Data from older adults were collected in the lab as well as in other controlled environments
-> Expected differences were found for both populations via t-tests

Final Deliverable

Validity

•Validity of Manipulations established (i.e., subjects "interpret" the manipulations as they are supposed to, implying the manipulations are what they are supposed to be) via **manipulation checks**

•Instrument validation

Figure 5.3 Pre-Test of Experimental Manipulations

The first step involved identifying whether the traditional version of the task with pictures or the arithmetic version outlined in the preceding chapter had higher validity for this study. Consistent with our discussion of the criteria for task selection in the preceding chapter, we sought to identify the version that was more mentally demanding. Mental resource demands were important because our theory argues that T-M interruptions can reduce the mental resources available for a task by entering working memory, thereby interfering with current task processing. Selecting a mentally demanding task ensured that T-M interruptions would relatively quickly reduce the working memory capacity available for the task and interfere with task-related information processing. Otherwise, if the task had required relatively few mental resources, T-M interruptions may have been less relevant; they could have been more easily processed in addition to the task. Further, to increase the relevance of this research, we aimed to be consistent with real-world computer-based tasks, which place relatively high mental demands on individuals (Birdi & Zapf, 1997).

In Phase 1 of this examination of the nature of the task, ten students played the game in both versions in a controlled setting. Findings from verbal protocols and quantitative analyses showed that the arithmetic version of the game was significantly more mentally demanding (mean demand for the arithmetic version = 4.7 on a 7-point scale, mean demand for the traditional version with pictures = 3.0, mean difference significant at the 0.05 level) and that a duration of six minutes was optimal before fatigue set in. After modifying the task by incorporating more difficult arithmetic equations and a larger number of pictures, we repeated this examination in a research laboratory that was subsequently used for the remainder of this study. Using white noise (i.e., a random signal with a flat power spectral density often applied to mask distracting sounds) to reduce potential outside noise distractions and five subjects, we again found that the arithmetic version was more mentally demanding (mean demand for the arithmetic version = 5.4, mean demand for the traditional version with pictures = 3.3, mean difference significant at the 0.10 level), leading us to conclude that the arithmetic version had greater validity for this study.

Next, we examined what degree of interruption complexity (i.e., the number of simultaneously appearing interruptions) constituted a valid stimulus for attentional inhibition. Using white noise and eight participants, we found that four interruptions at a time were significantly more difficult to inhibit than two at a time (mean difficulty to inhibit four interruptions at a time = 3.2 on a 7-point scale, mean difficulty to inhibit two interruptions at a time = 2.1, mean difference significant at the 0.05 level). Since any value greater than four may have had the opposite effect due to increasing predictability of spatial location (Carlson et al., 1995), it was concluded that four interruptions at a time was an appropriate level of interruption complexity for this study.

Following the specification of interruption complexity, we pre-tested interruption frequencies with 24 students and 13 older adults in controlled settings. The order of presentation of the interruption frequencies was counterbalanced across participants. As in prior steps of our pre-testing effort, we collected both quantitative and qualitative data. We found that interruptions appearing every 15 seconds constituted a valid manipulation for the higher frequency condition, while interruptions appearing every 90 seconds was a valid manipulation for the lower condition (mean perceived frequency for the higher frequency condition = 5.3 on a 7-point scale, mean perceived frequency for the lower condition = 2.1, mean difference significant at the 0.05 level).

Finally, we tested different colors (i.e., our operationalization of interruption salience) with 12 students and 13 older adults in controlled settings. The order of presentation of the interruption colors was counterbalanced across participants. By collecting and analyzing both quantitative and qualitative data, we found that a gray border around the interruptions constituted a valid manipulation for the lower salience condition, while a red border around the interruptions was a valid manipulation for the higher salience condition (mean perceived salience for the higher salience condition = 5.1 on a 7-point scale, mean perceived salience for the lower salience condition = 3.5, mean difference significant at the 0.05 level). Illustrative findings from verbal protocols include: “Red was more aggressive,” “Red interruptions were absolutely more noticeable,” “Gray blended in with the background,” “The gray messages aren’t as noticeable. The red ones you see immediately,” and “The red ones have stressed me more.”

In addition to establishing the validity of our experimental manipulations, the pre-test also showed that the memory game Concentration had good validity for this study. For example, a participant indicated that “You must be very concentrated in this game to be successful.” Further, the pre-test indicated that the manipulations would show the effects predicted for the core model. Illustrative findings from verbal protocols include: “I liked the game better without the messages; I tried to memorize a number, then the messages came and I forgot the number. The messages made it more difficult to concentrate on the game,” “Without the messages, you can concentrate better on the numbers. When the messages appear, you are distracted for a while. You could be focused more if the messages wouldn't appear quite as often," "These messages are very distracting," "When I am confused and stressed, I can't even do simple calculations anymore," and "I was totally confused because of the messages and couldn't do anything anymore."

As a result of pre-testing the experimental materials, we also made changes to the experimental procedure and protocol. First, we moved the Stroop task to the end of the experiment since this task was determined to be stressful in and of itself and may have, thus, confounded the results from the Concentration task. Second, we expanded the experimental protocol to require participants not to use their own personal electronic devices (e.g., phones, music players, tablet computers) at any time during the experiment. They were given magazines to read to prevent boredom. Third, the experimental protocol was expanded so that the participants were explained that all measures taken would be inherently non-intrusive. Similarly, an expansion was made to establish the credibility of the investigator. These changes were made so that the participants would not become anxious just by entering the research laboratory. Finally, the administration of the mouth rinsing procedure was adjusted to help participants ease into the laboratory experiment.

5.2.2 SURVEY INSTRUMENT

Below, we first describe how the survey instrument was developed, including relevant decisions concerning the administration of the instrument. Following this, we describe the pre-tests undertaken to evaluate and adjust the survey instrument.

5.2.2.1 Development of the Survey Instrument

In conjunction with the development of the experimental task and procedures, we also developed the survey instrument. As outlined in the preceding chapter, we used existing measures when available, supplemented with new scales developed specifically for this research. Figure 5.4 details the instrument development process, which followed commonly accepted guidelines (e.g., Churchill, 1979; Straub, 1989; Straub et al., 2004). To ensure adequate content validity, we began the scale development process by detailing construct definitions that could serve as a basis for the generation of sample items. Then, we developed a list of sample items and subjected those to three face and content validity checks as well as two item-sorting tasks, which resulted in a revised list of candidate items. These candidate items were then pre-tested using computer-based administration.

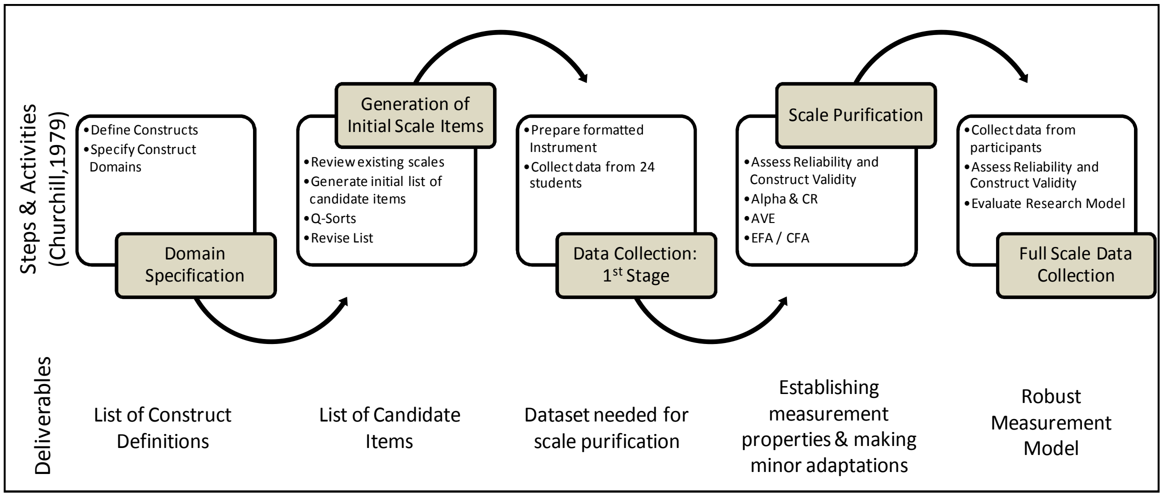


Figure 5.4 Scale Development Process

It was decided to administer the survey instrument as a computerized rather than a paper-and-pencil version since recent research indicates that computerized instruments are preferred by research participants (even older ones) and yield the same results (e.g., Cao et al., 2009; Collerton et al., 2007; Noyes & Garland, 2007). For example, Collerton et al. (2007) compared the acceptability and feasibility of computerized as well as paper-and-pencil tests of cognitive function in eighty-one older individuals. Specifically, they examined psychometric utility, participant acceptability, completion rates, time taken, and validity as cognitive measures. The researchers found that both types of media were equally good measures of cognitive function. More importantly, they also found that the older participants felt less stress when taking the computerized version compared to the paper-and-pencil version. They concluded that while both computerized and paper-and-pencil tests are feasible and useful means of assessing cognitive function in older individuals, computerized versions were preferred by the participants.

Similarly, Noyes and Garland (2007) examined whether differences exist between computer-based and paper-based versions of the NASA TLX, the measure of perceived mental workload employed in this study. They concluded that – in part because the display technology has improved so that computerized versions are substantially less tiring today than they were in the 1990s – computer and paper equivalence is largely found today and is reflected in people’s preferences. Consistent with this conclusion, anecdotal evidence from the Cognition, Aging, and Technology Lab at Clemson University shows that older people have fewer problems with the computerized version of the TLX, which is less confusing than the paper-based version (M. Price). Further, Cao et al. (2009, p. 114) and several other scholars reported that the magnitudes of the ratings on the TLX were "extremely consistent" between the two media.

Many other studies reported similar findings for paper-based vs. computerized measures in general (e.g., Hallfors et al., 2000; Hansen et al., 1997; Horton & Lovitt, 1994; Pinsoneault, 1996; Vispoel, 2000; Vispoel et al., 2001). In addition, Mead and Drasgow (1993), in their meta-analysis on the level of equivalence of computerized and paper-and-pencil versions of cognitive ability tests, found that there are no differences between these media for the verbal and quantitative abilities measured by the Graduate Record Examination (GRE®).

5.2.2.2 Pre-Testing of the Survey Instrument

As part of our pre-test, the list of candidate items for the survey instrument was evaluated for scale purification purposes. More specifically, the pre-test of the survey instrument had two major objectives:

1. Evaluation of Scale Reliability
2. Evaluation of Construct Validity

The survey instrument was first administered to 42 respondents for an initial round of scale purification. As is common in initial scale purification, few scales exhibited lack of reliability and construct validity. After these scales were revised, they were administered to another sample of 24 respondents and, subsequently, checked for reliability and validity for another round of scale evaluation. 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 inter-construct correlations. Thus, the instrument was considered reliable and valid.

5.2.3 PILOT-TESTING

Following the development of our preliminary instrument, we conducted a pilot study, simulating the full-scale experiment. The pilot required the participants to sign the approved Informed Consent Letter, and it was ensured that the subjects believed they were participating in the full-scale experiment to ensure a proper simulation. The pilot study had three major objectives (Dennis & Valacich, 2001; Lim & Benbasat, 2002):

1. Uncovering logistical problems.
2. Establishing the final estimate of the total time required to complete the entire procedure, from subject briefing to debriefing.
3. Obtaining a first impression of the directions of the means.

The pilot study was conducted with seven younger and five older adults. As shown in Table 5.1, the experimental procedures operated as intended (NC3R^s, 2006). More specifically, the procedures and instructions were clear to the investigator, who was also sufficiently skilled to conduct the study, the equipment operated as expected, the participants had no difficulties understanding and doing the experimental task, the task was neither too easy nor too difficult, and no adverse health effects could be observed in the pilot study participants. Further, we found that approximately 120 minutes were required to complete the entire experiment

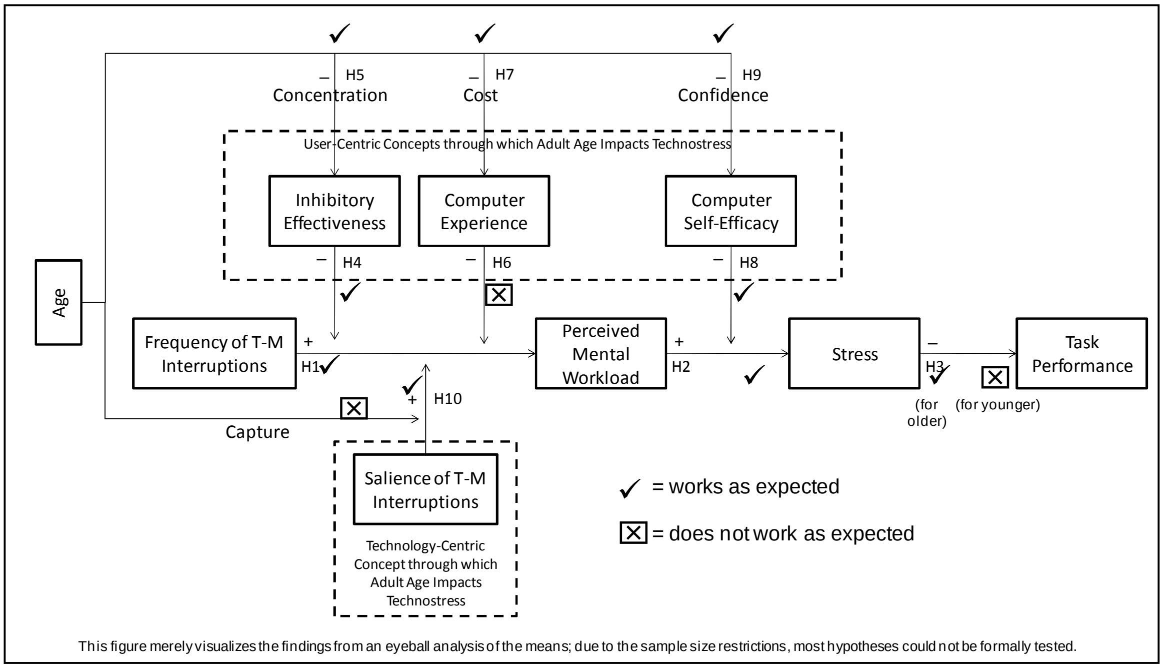
Logistical Issue	Acceptable
Check that the instructions given to investigators (e.g. randomisation procedures) are comprehensible	✓
Check that investigators and technicians are sufficiently skilled in the procedures	✓
Check the correct operation of equipment	✓
Check that the experimental subject can perform a task (physical or cognitive)	✓
Detect a floor or ceiling effect (e.g. if a task is too difficult or too easy there will be skewed results)	✓
Identify adverse effects (pain, suffering, etc.) caused by the procedure	✓

Table 5.1 Pilot-Test of Experimental Procedures

Concerning the directions of the means, we found support for:

- a main effect of interruption frequency on perceived mental workload for both age groups
- an interaction effect of interruption frequency and salience on perceived mental workload
- the expected age difference for inhibitory deficit (mean for older participants 94, mean for younger 52, mean difference significant at the 0.05 level)
- the expected age difference for computer experience (mean for older participants 4.3, mean for younger 5.8, mean difference significant at the 0.01 level)
- the expected age difference for computer self-efficacy (mean for older participants 3.9, mean for younger 5.1, mean difference significant at the 0.01 level)
- an association between perceived mental workload and salivary Alpha-Amylase (sAA)
- an association between sAA and task performance
- an interaction effect of interruption frequency and inhibitory control on mental workload
- and an interaction effect of perceived mental workload and CSE on sAA.

However, due to the relatively small sample size of this pilot, only few of these relationships could be confirmed through formal significance tests. Further, we did not find support for the interaction effect of interruption frequency and computer experience on perceived mental workload as well as for the 3-way interaction among interruption frequency, interruption salience, and participant age. Based on these results (see Figure 5.5 and Table 5.2), the frequency for the higher interruption frequency condition was increased to 10 seconds, and it was concluded that the experimental design was finalized.



This figure merely visualizes the findings from an eyeball analysis of the means; due to the sample size restrictions, most hypotheses could not be formally tested.

Figure 5.5 Pilot-Test Results for Directions of Means

Workload by Condition for Younger Participants					
Frequency of T-M interruptions		Low		High	
Salience of T-M interruptions		Low	High	Low	High
Mental Workload	Mean	51	46	52	57
	Median	52	48	63	70

Workload by Condition for Older Participants					
Frequency of T-M interruptions		Low		High	
Salience of T-M interruptions		Low	High	Low	High
Mental Workload	Mean	53	48	63	59
	Median	53	48	64	61

Workload, Stress, and Performance for Older Participants				
	Performance	Perceived Stress	Salivary Stress	Mental Workload
Performance	1.00			
Perceived Stress	0.84	1.00		
Salivary Stress	-0.33	-0.04	1.00	
Mental Workload	0.34	0.41	0.52	1.00

Workload, Stress, and Performance for Younger Participants				
	Performance	Perceived Stress	Salivary Stress	Mental Workload
Performance	1.00			
Perceived Stress	0.11	1.00		
Salivary Stress	0.58	0.20	1.00	
Mental Workload	0.09	0.64	-0.07	1.00

Table 5.2 Pilot-Test Results for Directions of Means

5.2.4 PRELIMINARY RESULTS

Preliminary analyses were conducted to derive an initial evaluation of the theory once approx. 40% of the final data were collected. In these preliminary analyses, we found support for all hypotheses except the 3-way interaction among interruption frequency, interruption salience, and participant age (see Table 5.3). First, we found that interruption frequency had a main effect on perceived mental workload. Second, we found that perceived mental workload served as a significant predictor of perceived stress, which, in turn, was found to serve as a predictor of the number of matching pairs uncovered in the Concentration task. Using the Sobel test (Sobel, 1982) and the bootstrapping procedure (Preacher & Hayes, 2004) to test for the significance of the indirect effects, we also found that mental workload served as a full mediator between interruption frequency and individual stress, which, in turn, served as a partial mediator between mental workload and task performance. Hence, the full baseline model was supported.

Hypothesis			
Number	*Statement*	*b*	*$p < 0.05$*
1	The frequency of T-M interruptions is positively related to perceived mental workload.	6.117	✓
2	Perceived mental workload is positively related to individual stress.	0.028	✓
3	Individual stress is negatively related to task performance.	-2.994	✓
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.	0.185	✓
5	Older compared to younger people have lower levels of inhibitory effectiveness.	n/a	✓
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.	-10.400	✓
7	Older compared to younger people have lower levels of computer experience.	n/a	✓
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.	-0.014	✓
9	Older compared to younger people have lower levels of computer self-efficacy.	n/a	✓
10	The salience of T-M interruptions and age moderate the effect of the frequency of T-M interruptions on perceived mental workload so that differences in the effectiveness of the frequency of T-M interruptions on the basis of the salience of T-M interruptions are stronger for older compared to younger people.	n/a	☒

Legend: n/a = not applicable

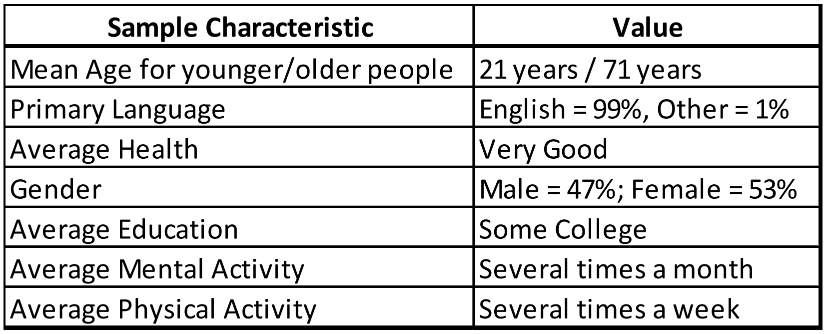
Table 5.3 Support for Hypotheses Provided by the Preliminary Results

For age-related manifestations, we found that our measure of inhibitory effectiveness interacted with interruption frequency to affect perceived mental workload and, as expected, that older participants inhibited less well than younger people. We further found that computer experience interacted with interruption frequency to affect mental workload and that older people had significantly lower levels of computer experience than younger. Also, the results showed that CSE interacted with mental workload to affect individual stress. Consistent with our expectations, older people reported significantly lower levels of CSE than younger people did.

However, the lack of support found for the 3-way interaction among interruption frequency, interruption salience, and participant age was unexpected. It was examined whether the salience manipulation could be strengthened by increasing the reddishness of the higher salience manipulation, but it was found that this manipulation was at its maximum strength. Hence, the non-significant result was attributed to the general difficulty of detecting 3-way interactions in small samples (Cohen et al., 2003). On the basis of these results, it was concluded that no significant changes to the research instrument were necessary and that the data collection process should proceed as planned. The following sections and subsections report the results from the main experiment.

5.3 SAMPLE CHARACTERISTICS

A total of 128 individuals participated in the experiment, 64 younger and 64 older people. Consistent with prior research in the areas of technostress and aging, younger participants were recruited from undergraduate classes at a large southeastern university, and older participants were recruited from the local community through contacts provided by one of this dissertation’s committee members (Galluch, 2009; Darowski et al., 2008; Pak et al., 2009). Among younger participants, the average age was 21, while it was 71 among the older participants. English was the primary language for 99% of the participants, and most participants were in very good health (mean of 3.8 on a 5-point scale). In addition, 47% of the participants were male. Moreover, the average participant was college-educated (mean of 5.2 on an 8-point scale, SD of 1.03) and engaged several times a month in mental activities (e.g., crossword puzzles, checkers) (mean of 3.25 on a 5-point scale, SD of 1.08) as well as several times a week in physical activities (e.g., running, swimming) (mean of 3.72 on a 5-point scale, SD of 0.84) (see Table 5.4).



Sample Characteristic	Value
Mean Age for younger/older people	21 years / 71 years
Primary Language	English = 99%, Other = 1%
Average Health	Very Good
Gender	Male = 47%; Female = 53%
Average Education	Some College
Average Mental Activity	Several times a month
Average Physical Activity	Several times a week

Table 5.4 Sample Characteristics

5.4 MEASUREMENT PROPERTIES

Below we detail the descriptive statistics and quality criteria of our measures and manipulations, including the correlations between the construct measures used in this study (see Table 5.5). Before calculating these statistics, we verified that our data met the major assumptions of RM-ANOVA. More specifically, we verified normality by checking for skewness and kurtosis and, where appropriate, transformed a variable by taking its square root in the case of moderate deviation from normality and its logarithm in the case of severe deviation. Skewness and kurtosis statistics and standard errors are shown in Table 5.6. Further, using Levene's test of homogeneity of variance, we verified that younger and older people had equal variances on our interval dependent variables ($p > 0.05$ on Levene's test). A major assumption specific to RM-ANOVA is sphericity, which assumes that the variances of and the correlations among the repeated measures are all equal. However, since this assumption is relevant only for repeated measure variables with three or more categories, it does not apply to this research, which uses repeated measure variables with two categories (Cohen et al., 2003).

Variables	1	2	3	4	5	6	7	8	9
1 Interruption Frequency	1.00								
2 Age	0.00	1.00							
3 Inhibitory Deficit	0.00	0.21 *	1.00						
4 Computer Experience	-0.02	-0.52 **	-0.29 **	1.00					
5 Computer Self-efficacy	-0.04	-0.61 **	-0.14	0.61 **	1.00				
6 Mental Workload	0.17	-0.04	0.11	-0.10	-0.03	1.00			
7 Perceptual Stress	0.08	0.12	0.29 **	-0.26 **	-0.23 *	0.41 **	1.00		
8 Hormonal Stress	0.15	0.27 **	0.11	-0.17	-0.11	0.21 *	0.00	1.00	
9 Task Performance	-0.01	-0.77 **	-0.26 **	0.52 **	0.53 **	0.01	-0.17	-0.18	1.00
Mean	0.50	0.50	67.82	4.51	4.72	54.34	2.35	40.11	40.16
Standard Deviation	0.50	0.50	131.32	0.94	1.36	13.77	0.97	37.06	15.72
* and ** indicate significance at 0.05 and 0.01 levels, respectively. SPSS 15.0 was used for computation.									

Table 5.5 Correlation Matrix

Variable	Skewness		Kurtosis	
	Statistic	**Std. Error**	**Statistic**	**Std. Error**
Mental Worload for Gray Interruptions	-0.212	0.223	-0.408	0.442
Mental Workload for Red Interruptions	-0.265	0.223	-0.619	0.442
Perceived Stress for Gray Interruptions	0.054	0.224	-0.553	0.444
Perceived Stress for Red Interruptions	0.428	0.223	-0.284	0.442
Salivary Stress for Gray Interruptions	-0.384	0.222	0.636	0.440
Salivary Stress for Red Interruptions	-0.229	0.222	0.210	0.440
Performance for Gray Interruptions	0.371	0.218	-0.673	0.433
Performance for Red Interruptions	0.076	0.218	-0.885	0.433

Table 5.6 Skewness and Kurtosis Values and Standard Errors

5.4.1 EXPERIMENTAL MANIPULATIONS

We conducted manipulation checks to verify the validity of our interruption frequency and color manipulations. The mean for lower perceived frequency was 3.01 (SD=1.03) on a 7-point scale, whereas the mean for higher perceived frequency was 4.84 (SD=1.09), a difference that was significant at the 0.001 level. A sample item is “Interruptions appeared very frequently during the task.” For the salience manipulation, the mean for lower perceived salience was 4.08 (SD=1.22) on a 7-point scale, whereas the mean for higher perceived salience was 4.65 (SD=1.44). This difference was significant at the 0.001 level. A sample item is “The interruptions seemed to "pop out" of the computer display.” Based on these results, we concluded that the participants perceived our manipulations as intended, implying that our manipulations were valid.

5.4.2 SURVEY INSTRUMENT

Evaluating the quality of our survey instrument included estimating the reliability as well as the convergent and discriminant validity of the latent variable indicators. SPSS® 15.0 was used to calculate all statistics, which were obtained through a factor analysis with Maximum Likelihood extraction and Promax rotation[13]. Six factors were specified for extraction since we analyzed the indicators associated with six different constructs. Perceptual Stress was separated into stress for red and gray interruptions since the use of RM-ANOVA requires the data to be restructured so that variables that were

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[13] In contrast to the traditional orthogonal rotation methods (e.g., Varimax), oblique rotation methods such as Promax allow the factors to be inter-correlated and are, therefore, generally preferred (Tabachnick & Fidell, 2007).

measured repeatedly (stress in this case) have separate scales for the different categories of the repeated measure (red and gray in this case).

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 for the present study exceeded this threshold, indicating satisfactory internal consistency reliability (see Table 5.7).

	Number of Items	AVE	AVE Non-Associated Items	Alpha	Mean	SD
Computer Self-Efficacy	10	0.70	0.004	0.96	4.72	1.36
Perceptual Stress for Red Interruptions	5	0.65	0.005	0.92	2.32	1.07
Memory Game Concentration Experience	5	0.68	0.002	0.87	2.30	1.21
Perceptual Stress for Gray Interruptions	5	0.63	0.003	0.91	2.29	1.05
Memory Game Concentration 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

AVE = Average Variance Extracted

Table 5.7 Quality Criteria and Descriptives of Latent Variables

Convergent validity reflects the extent to which the indicators of a construct converge on it, representing their relationship in reality. It is increasingly evaluated on the basis of a construct’s average variance extracted (AVE), which quantifies the amount of variance a latent variable captures from its associated items relative to the amount that is due to measurement error. The convergent validity of a construct is generally considered satisfactory when its AVE is at least 0.50 (Fornell & Larcker, 1981), indicating that the majority of the variance is accounted for by the construct. The discriminant validity of a construct reflects the extent to which the construct differs from others in the model. It is considered satisfactory when the square root of the construct’s AVE is larger than the inter-construct correlations (Chin, 1998). In our model, all AVE values exceeded 0.50 (see Table 5.7), and the square root of each construct's AVE was higher than the correlations between that construct and all others (see Table 5.8), indicating satisfactory convergent and discriminant validity. Moreover, the AVE value for non-associated items, which quantifies the amount of variance a latent variable captures from the items it is not associated with relative to the amount due to measurement error (Fornell & Larcker, 1981), was less than 0.01 for each construct (see Table 5.7), further confirming good construct validity.

	CSE	**ConcExp**	**Stress.Red**	**Stress.Gray**	**ConcSE**	**CE**
Computer Self-Efficacy (CSE)	**0.835**					
Stress for Red Interruptions (Stress.Red)	0.288	**0.822**				
Memory Game Concentration Experience (ConcExp)	-0.201	0.041	**0.806**			
Stress for Gray Interruptions (Stress.Gray)	-0.113	-0.087	0.571	**0.793**		
Memory Game Concentration Self-Efficacy (ConcSE)	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**
Diagonal Elements are Square Roots of the Average Variance Extracted						

Table 5.8 Latent Variable Correlations

Convergent and discriminant validity are further confirmed when the indicators load above 0.50 on their associated latent variables and when the loadings within constructs are higher than those across constructs (Chin, 1998). Table 5.9 presents the loadings of indicators on their associated and other latent variables for this study that were obtained from the previously mentioned factor analysis with Maximum Likelihood extraction and Promax rotation, in which six factors were specified for extraction. Visual inspection of these loadings and cross-loadings further confirms that all constructs have satisfactory convergent and discriminant validity. All indicators loaded higher than 0.50 on their associated constructs, and all indicators loaded higher on their associated constructs than on other constructs.

	Computer Self-Efficacy (CSE)	Memory Game Concentration Experience (ConcExp)	Stress for Red Interruptions (Stress.Red)	Stress for Gray Interruptions (Stress.Gray)	Memory Game Concentration Self-Efficacy (ConcSE)	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
ConcExp1	-0.055	0.886	0.027	-0.010	0.026	0.038
ConcExp2	0.012	0.979	-0.020	0.023	-0.064	-0.034
ConcExp3	-0.003	0.952	0.024	-0.031	-0.019	-0.049
ConcExp4	0.026	0.610	-0.026	0.008	0.221	0.108
ConcExp5	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
ConcSE1	0.062	0.098	0.047	-0.012	0.545	0.133
ConcSE2	0.101	-0.064	-0.011	-0.019	0.928	-0.059
ConcSE3	-0.021	0.003	-0.051	0.025	0.978	-0.022
ConcSE4	-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

Table 5.9 Loadings and Cross Loadings of Latent Variable Indicators

Since common method bias generally threatens inferences of causality in behavioral science research, we used both procedural and statistical remedies to control for method bias (Podsakoff et al., 2003). For procedural remedies, we attempted to reduce common method bias through the design of our study by embedding 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. First, we measured constructs through multiple methods when possible. For example, individual stress was captured subjectively through self-reports on a 7-point Likert type scale and objectively through salivary Alpha Amylase. We also varied the anchors of our measures. For example, while stress was measured on a 7-point scale, physical activity was measured on a 5-point scale.

Second, we separated the measurement of our independent and dependent variable pairs across the entire research model (see Figure 5.6). For example, for H1, the interruption frequency was an objective manipulation, whereas mental workload was a subjective evaluation. For H2, this subjective evaluation of perceived mental workload was, in turn, related to an objective measure of stress (sAA). Additionally, the subjective evaluation of perceived mental workload was related to a subjective measure of stress; yet, both subjective measures were captured through different techniques, the NASA TLX and a 7-point Likert-type scale. For H3, the objective and subjective measures of stress were related to an objective measure of task performance. Further, two distinct surveys were administered at different times during the experiment to capture the perceptual stress and individual difference variables, ensuring that method bias had little influence on the relationship between stress and computer self-efficacy (CSE). A memory task survey included the manipulation checks for interruption frequency and salience as well as the stress measure, while an individual difference survey – administered at a different time – contained the CSE measures, among others.

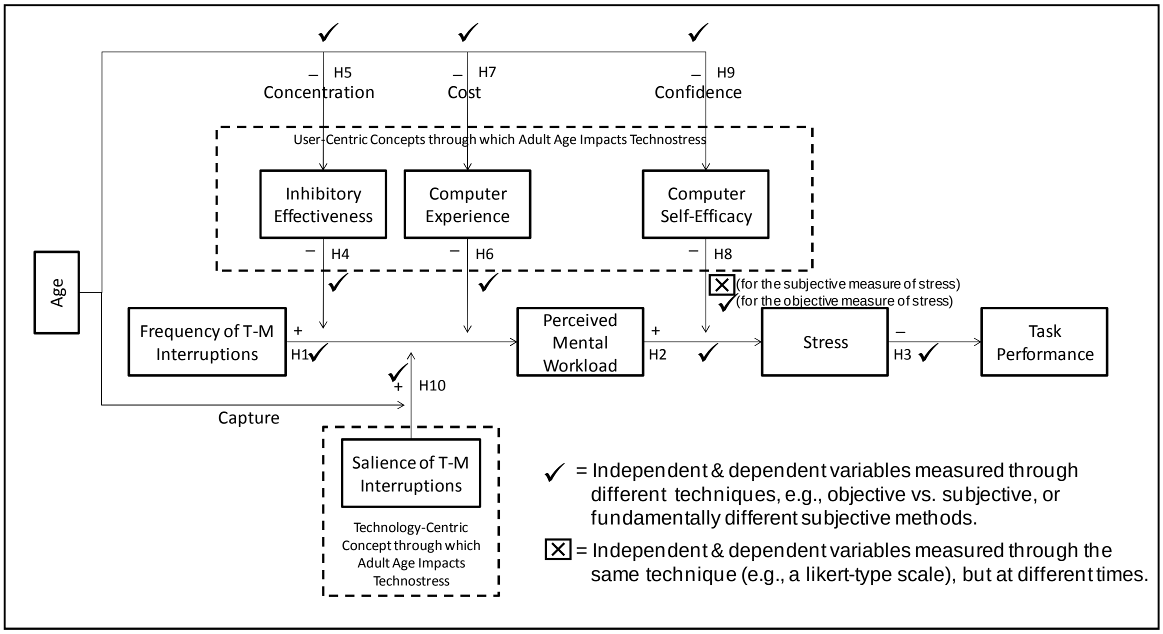

Figure 5.6 Separation of Measurement Techniques for the Independent and Dependent Variable Pairs

Furthermore, we assured our participants that their answers were anonymous, and we ensured that no personally identifying information was shown or entered in any survey we administered. This guarantee was repeated in the informed consent form the participants signed. We also assured our participants that there were no right or wrong answers, and we asked them to respond to all questions as honestly as possible. Moreover, social desirability biases and fundamental attribution errors were unlikely to occur in this study since it did not ask participants to rate their performance or other similarly sensitive subjects. As a result of all these precautions, the likelihood of common method bias to occur was effectively reduced.

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 (Mossholder et al., 1998; Malhotra et al., 2006;

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. The underlying logic is that if the variation among the indicators is due to method bias, a single (method) factor should fit the data (Podsakoff & Organ, 1986). In our data, a one-factor model exhibited substantial misfit (χ^2 [464] = 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 ($\Delta\chi^2$ [145] = 1,918.82, $p < 0.001$), indicating that common method variance was not found[14].

5.5 HYPOTHESES TESTING

5.5.1 OVERVIEW OF HYPOTHESES TESTING

The model was tested in five steps (see Figure 5.7). Within each step, an outlier analysis was conducted (e.g., discrepancy, leverage statistics) and a series of models were estimated to evaluate all hypotheses pertaining to that step. Despite the removal of nine outlier cases we exceeded the threshold of 90 for a power level of 0.80 derived from our power analysis[15]. The sample sizes in Steps 1, 2, 3, 4, and 5 were 94, 117, 119, 118, and

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[14] The test has the limitation that it may confound method with trait effects since not both are incorporated simultaneously in the same model. However, the large number of procedural remedies employed in combination with the test results suggest that common method variance was not a problem.

[15] Outlier statistics were plotted using histograms, which were evaluated on the basis of commonly accepted guidelines (e.g., outliers exhibiting large gaps in the discrepancy value from the remainder of the cases merit particular attention) in combination with generally recommended cutoff values (±2 and $2[k+1]/n$ for discrepancy and leverage, respectively, where k is the number of IVs and n is the sample size) (Cohen et al., 2003; Tabachnick and Fidell, 2007). The one non-native English speaker did not stand out as an outlier and did not affect the results. When the analyses were conducted using the complete dataset (no outliers removed), Hypotheses 5, 7, and 9 were supported, whereas Hypotheses 1-4, 6, 8, and 10 were either not supported or only marginally supported. However, Hypotheses 1-4, 6, and 8 were supported in the partial dataset as shown in the next sections and subsections, implying that the results were – as expected – sensitive to the outlier removal (Cohen et al., 2003).

119, respectively, for perceptual stress (except for the first step, which did not include the stress concept, all analyses were conducted separately for the perceptual and hormonal measures of stress). For hormonal stress, they were 94, 119, 119, 118, and 119. 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 within this step. Step 2 included all tests relevant to the link between mental workload and stress; thus, H2, H8, and H9 were evaluated within this step. Step 3 included the tests pertaining to the link between stress and task performance; accordingly, H3 was tested within this step. Finally, Step 4 tested whether mental workload acted as a mediator between interruption frequency and stress, and Step 5 evaluated whether stress, in turn, acted as a mediator between mental workload and performance.

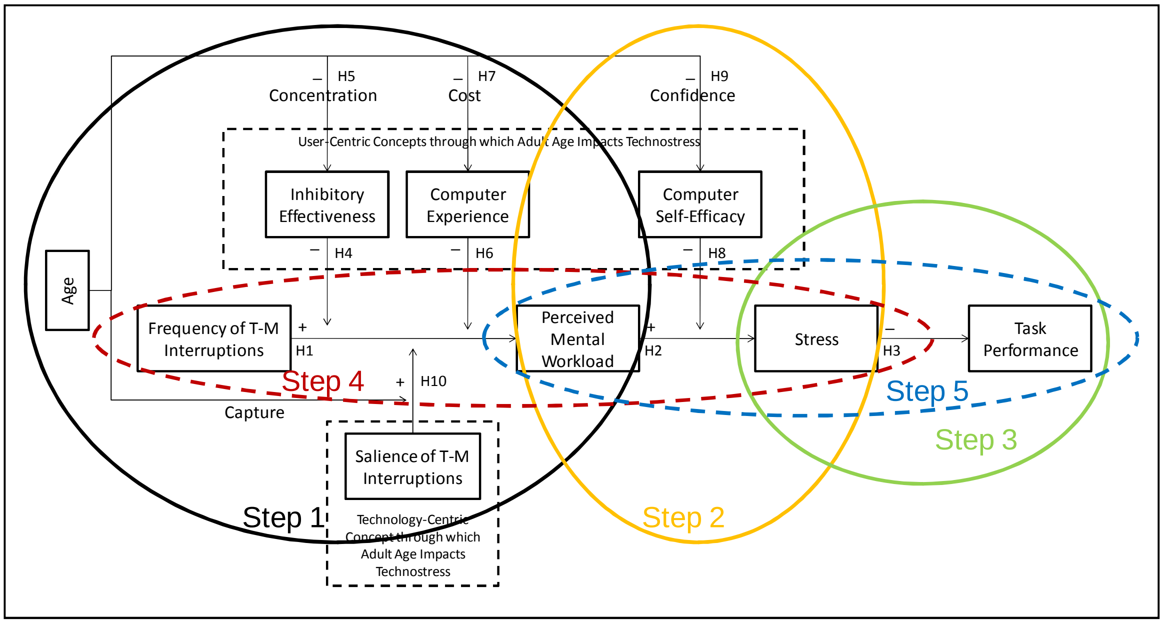


Figure 5.7 Steps Involved in Hypothesis Testing

Repeated Measures ANOVA was used to test Hypotheses 1, 2, 3, 4, 6, 8, and 10. Independent samples t-tests comparing younger and older participants were used to test Hypotheses 5, 7, and 9. In Steps 4 and 5, formal mediation analyses were conducted using the Sobel test (Sobel, 1982) and the bootstrapping procedure (Preacher & Hayes, 2004) to evaluate directly the indirect effects. The next sections report the results from the hypotheses tests.

5.5.2 STEP1: THE EFFECT OF INTERRUPTIONS ON MENTAL WORKLOAD

Below, we present the results for the first step of our model test, which evaluates the six hypotheses pertaining to the link between interruption frequency and perceived mental workload (i.e., H1, H4, H5, H6, H7, and H10) (see Figure 5.8). Continuous independent variables were mean-centered prior to analysis to ensure stable intercepts (Cohen et al., 2003). To strengthen our ability to infer causality, we controlled for a number of factors based on prior research. We controlled for working memory capacity, short-term memory, age, and experience with as well as confidence regarding the memory game Concentration (Hart & Staveland, 1988; Sharit et al., 1998; Wierwille & Eggemeier, 1993; Yeh & Wickens, 1988).

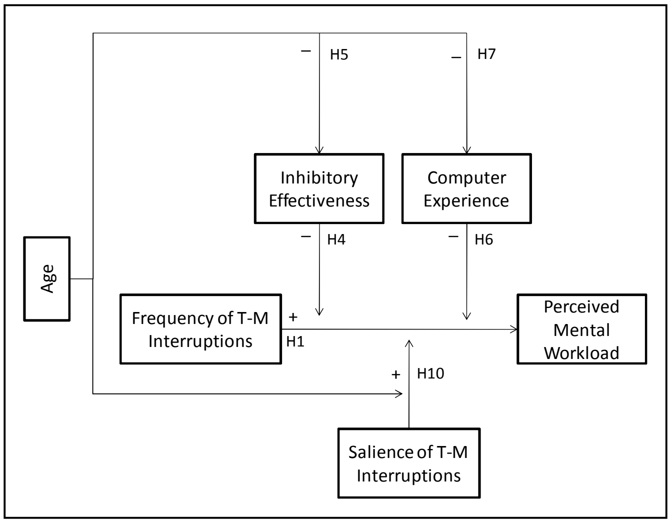


Figure 5.8 Hypotheses tested in Step 1

Hypothesis 1 stated that the frequency of T-M interruptions is positively related to perceptions of mental workload. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the positive direction as expected ($b = 8.335$, $F(1,93) = 8.756$, $p < 0.01$), implying that Hypothesis 1 was supported. The mean for mental workload for lower interruption frequency was 49.77, while the mean for mental workload for higher interruption frequency was 56.94 (see Figure 5.9). Hence, interruptions increased mental workload perceptions, implying that individuals faced difficulty managing the competing demands of the task and the interruptions for the limited capacity of working memory.

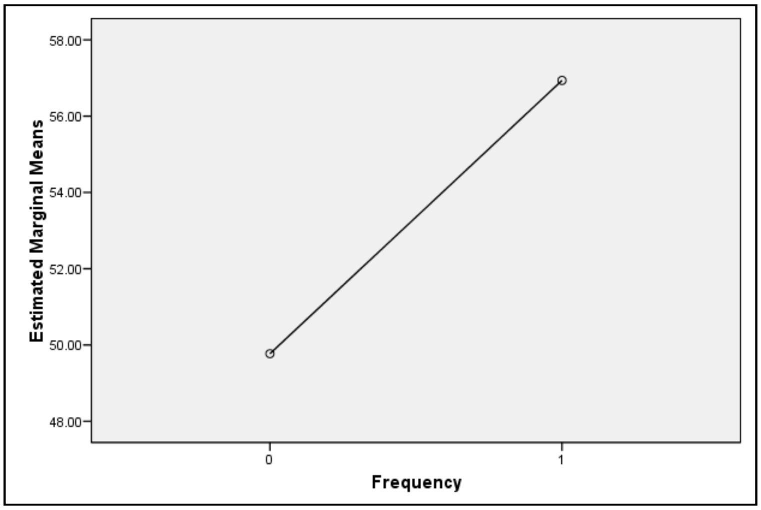


Figure 5.9 Mental Workload Means for Lower (0) and Higher (1) Interruption Frequencies

Hypotheses 2 and 3 were evaluated within analysis Steps 2 and 3. Hence, their results are discussed following Hypotheses 4, 5, 6, 7, and 10. Hypothesis 4 stated that 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. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the positive direction as expected ($b = 0.062$, $F(1,93) = 4.120$, $p < 0.05$), implying that Hypothesis 4 was supported. A positive interaction was expected since the Stroop task (i.e., our measure of inhibition) evaluates participants' inhibitory deficit, not their inhibitory effectiveness; larger values for the Stroop effect imply stronger inhibitory deficits. Following procedures recommended by Cohen et al. (2003), the predicted values for mental workload for the interruption frequency – inhibition interaction are given in Table 5.10 and plotted in Figure 5.10. As can be seen, interruption frequency had little impact on mental workload for people who inhibited well (one standard deviation below the mean), while it had a large impact on mental workload for participants who suffered from an inhibitory deficit (one standard deviation above the mean). Hence, the effect of interruptions depended on participants' inhibitory effectiveness; the better the participants could inhibit attentional responses to distracting stimuli, the less their mental workload perceptions were affected by the interruptions.

	Lower Frequency	Higher Frequency
Low Inhibitory Deficit = High Inhibitory Effectiveness	51.612	51.771
High Inhibitory Deficit = Low Inhibitory Effectiveness	47.682	63.561

Table 5.10 Predicted Workload Values for Lower/Higher Interruption Frequencies and Inhibitory Deficits

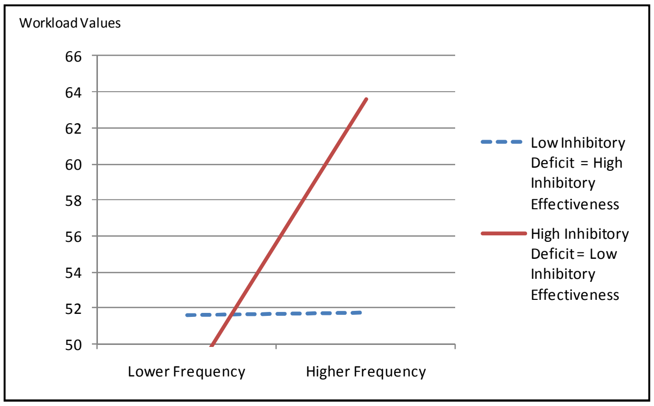
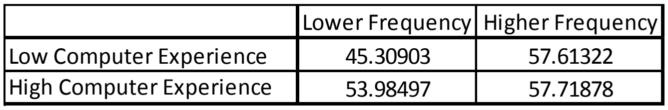


Figure 5.10 Predicted Workload Values for Lower/Higher Interruption Frequencies and Inhibitory Deficits

Hypothesis 5 stated that older people have lower levels of inhibitory effectiveness (i.e., higher levels of inhibitory deficits) than younger. An independent samples t-test was conducted to test this hypothesis. The test showed a significant difference (t (68) = -2.151, $p < 0.05$, equal variances not assumed) for inhibitory deficit between older and younger participants, implying that Hypothesis 5 was supported. The mean for inhibitory deficit for older people was 97.63 (SD=171.08), while it was 42.41 (SD=76.70) for younger participants, potentially implying that on average older people benefited less from the moderating impact of inhibition on the link between frequency and workload.

Hypothesis 6 stated that 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. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the negative direction as expected ($b = -8.823$, $F(1,93) = 5.295$, $p < 0.05$), implying that Hypothesis 6 was supported. People with higher levels of computer experience perceived lower workload manifestations as a result of T-M interruptions. The predicted values for mental workload for the interruption frequency – computer experience interaction are given in Table 5.11 and plotted in Figure 5.11. As can be seen, interruption frequency had a larger impact on mental workload for people with low levels of computer experience than high (one standard deviation below and above the mean, respectively). Hence, the effect of interruptions depended on participants' computer experience; the more computer experience they had, the less their mental workload was affected by the interruptions.



	Lower Frequency	Higher Frequency
Low Computer Experience	45.30903	57.61322
High Computer Experience	53.98497	57.71878

Table 5.11 Predicted Workload Values for Lower/Higher Frequencies & Levels of Computer Experience

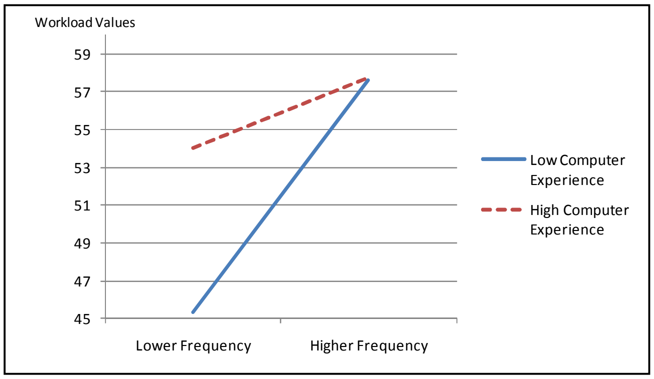


Figure 5.11 Predicted Workload Values for Lower/Higher Frequencies & Levels of Computer Experience

Hypothesis 7 stated that older people have lower levels of computer experience than younger. An independent samples t-test was conducted to test this hypothesis. The test showed a significant difference ($t(55) = 6.348$, $p < 0.001$, equal variances not assumed) for computer experience between older and younger subjects, implying that Hypothesis 7 was supported. The mean for computer experience for older people was 4.04 (SD=1.12), while it was 4.99 (SD=0.06) for younger participants, potentially implying that on average older people benefited less from the moderating impact of computer experience on the link between interruption frequency and mental workload.

Hypothesis 10 stated that the salience of T-M interruptions and age act as joint moderators in the relationship between the frequency of T-M interruptions and perceived mental workload. An RM-ANOVA was conducted to test this hypothesis. This ANOVA did not show a significant 3-way interaction ($F(1,98) = 3.081$, $p > 0.05$), indicating that H10 was not supported. We explore potential reasons for this finding in the next chapter.

5.5.3 STEP 2: THE EFFECT OF MENTAL WORKLOAD ON STRESS

Below, we present the results for the second step of our model test, which evaluated the three hypotheses pertaining to the link between perceived mental workload and individual stress (i.e., H2, H8, and H9) (see Figure 5.12). Continuous independent variables were mean-centered prior to analysis (Cohen et al., 2003). To strengthen our ability to infer causality, we controlled for several factors based on prior research. More specifically, we controlled for gender, education, age, and physical activity as well as for the intake of alcohol, caffeine, meals, and dairy products (Norris et al., 1992; Ragu-Nathan et al., 2008; Salimetrics, LLC, 2009; Unger et al., 1997; Wang et al., 2008). The two workload scores for gray and red interruptions were averaged prior to analysis due to their significant correlation ($r = 0.81$, $p < 0.01$) (Tabachnick & Fidell, 2007)[16]. We first report the results for perceived stress for H2, H8, and H9. Then, we detail the results for stress measured through sAA for H2 and H8.

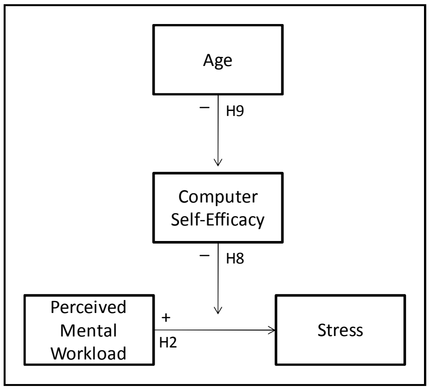


Figure 5.12 Hypotheses tested in Step 2

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[16] To additionally verify the appropriateness of averaging the measures, we also conducted the analyses in Step 2 separately for the two workload scores for gray and red interruptions. Conducting these separate analyses did neither change the results for the perceived nor for the hormonal measure of stress.

5.5.3.1 Perceptual Stress

Hypothesis 2 stated that perceptions of mental workload are positively related to individual stress. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the positive direction as expected ($b = 0.005$, $F(1,116) = 13.324$, $p < 0.01$), implying that Hypothesis 2 was supported. The predicted value for stress for low mental workload (one standard deviation below the mean) was 0.84, while the predicted value for stress for high mental workload (one standard deviation above the mean) was 0.98 (see Figure 5.13). Hence, mental workload perceptions appear to have imposed the threat of low performance on individuals and, thus, increased individual stress.

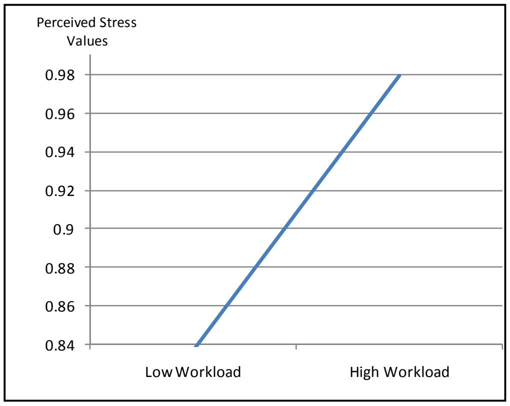

Figure 5.13 Perceived Stress for Low and High Workload Perceptions

Hypothesis 8 stated that 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. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the negative direction as expected (b = -0.003, F(1,116) = 5.118, $p < 0.05$), implying that Hypothesis 8 was supported. People with higher levels of CSE incurred lower stress manifestations because of mental workload. The predicted values for stress for the mental workload – computer self-efficacy interaction are given in Table 5.12 and plotted in Figure 5.14. As can be seen from the figure, mental workload had a larger impact on stress for people with low levels of CSE than high (one standard deviation below and above the mean, respectively). More specifically, for low levels of CSE, mental workload had a significant relationship with stress (t=3.90), while no significant relationship between mental workload and stress (t=0.40) could be observed for participants with high levels of CSE. Hence, the effect of mental workload depended on participants' CSE; the more CSE they had, the less their mental workload perceptions affected perceptions of stress.

	Low Mental Workload	High Mental Workload
Low Computer Self-Efficacy	0.85	1.10
HIGH Computer Self-Efficacy	0.83	0.86

Table 5.12 Predicted Values of Perceptual Stress for Low and High Levels of Mental Workload and CSE

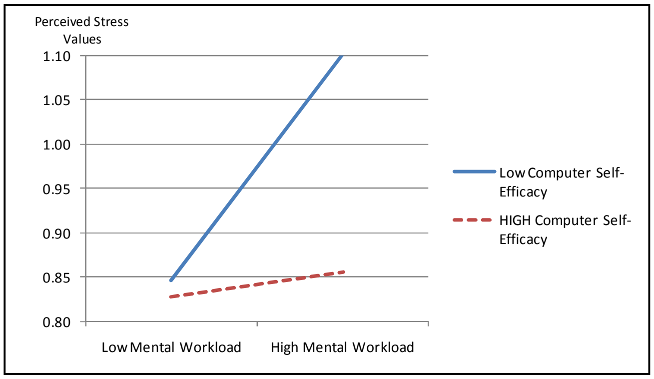

Figure 5.14 Predicted Values of Perceptual Stress for Low and High Levels of Mental Workload and CSE

Hypothesis 9 stated that older people have lower levels of computer self-efficacy than younger. An independent samples t-test was conducted to test this hypothesis. The test showed a significant difference ($t (89) = 8.049$, $p < 0.001$, equal variances not assumed) for CSE between older and younger participants, implying that Hypothesis 9 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 participants, potentially implying that on average older people benefited less from the moderating impact of computer self-efficacy on the link between mental workload perceptions and individual stress.

5.5.3.2 Salivary Alpha-Amylase

Hypothesis 2 stated that perceptions of mental workload are positively related to individual stress. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the positive direction as expected ($b =1.523$, $F(1,118) = 9.355$, $p < 0.01$), implying that Hypothesis 2 was supported. The predicted value for stress for low mental workload (one standard deviation below the mean) was 0.95, while the predicted value for stress for high mental workload (one standard deviation above the mean) was 1.38 (see Figure 5.15). Thus, perceptions of mental workload seem to have imposed the threat of low performance on the participants and, hence, increased individual stress.

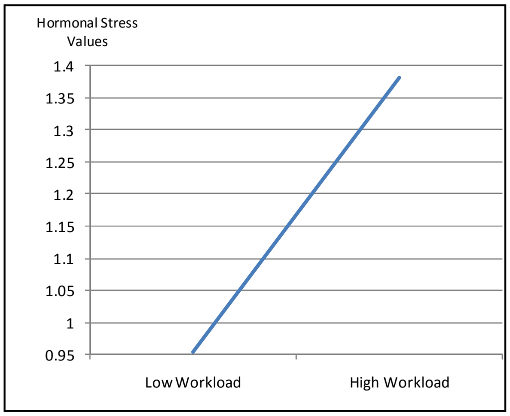

Figure 5.15 Hormonal Stress for Low and High Workload Perceptions

Hypothesis 8 stated that 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. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the negative direction as expected ($b = -2.245$, $F(1,118) = 9.266$, $p < 0.01$), implying that Hypothesis 8 was supported. People with higher levels of CSE incurred lower stress manifestations because of mental workload. The predicted values for stress for the mental workload – computer self-efficacy interaction are given in Table 5.13 and plotted in Figure 5.16. As can be seen from the figure, mental workload had a larger impact on stress for people with low levels of CSE than high (one standard deviation below and above the mean, respectively). More specifically, for low levels of CSE, mental workload had a significant relationship with stress ($t=4.55$), while no significant relationship between mental workload and stress ($t=-1.50$) could be observed for participants with high levels of CSE. Hence, the effect of mental workload depended on participants' CSE; the more CSE they had, the less their mental workload perceptions raised experiences of stress.

	Low Mental Workload	High Mental Workload
Low Computer Self-Efficacy	0.00	1.19
HIGH Computer Self-Efficacy	1.98	1.57

Table 5.13 Predicted Values of Hormonal Stress for Low and High Levels of Mental Workload and CSE

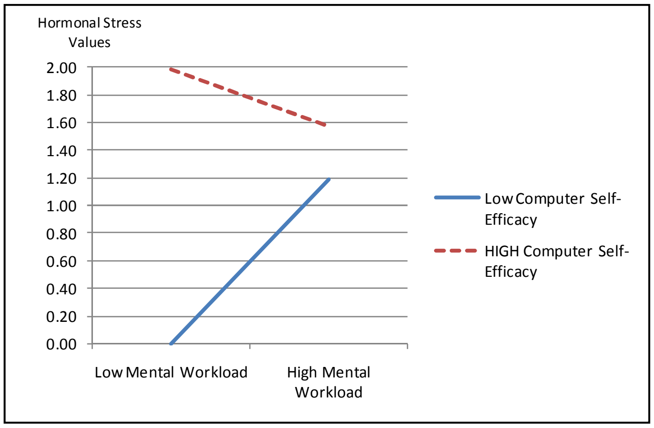

Figure 5.16 Predicted Values of Hormonal Stress for Low and High Levels of Mental Workload and CSE

5.5.4 STEP 3: THE EFFECT OF STRESS ON TASK PERFORMANCE

Below, we present the results for the third step of our model test, which evaluated the hypothesis pertaining to the link between individual stress and task performance (i.e., H3) (see Figure 5.17). Continuous independent variables were mean-centered prior to analysis (Cohen et al., 2003). To strengthen our ability to infer causality, we again controlled for a number of factors based on prior research. More specifically, we controlled for participants' math accuracy scores on an arithmetic test, education, gender, and mental activity (Baker-Ward & Ornstein, 1988; Newson & Kemps, 2006; Schumann-Hengsteler, 1996; Washburn et al., 2007; Wilson et al., 1999). The two stress scores for gray and red interruptions were averaged prior to analysis due to their significant correlations ($r = 0.57$ and $p < 0.01$ for perceived stress, $r = 0.81$ and $p < 0.01$ for sAA) (Tabachnick & Fidell, 2007). Moreover, no interactions with color were found for either the perceived or hormonal measure; the effect of stress on task performance did not depend on interruption salience[17]. We first report the results for perceived stress. Then, we detail the results for sAA.

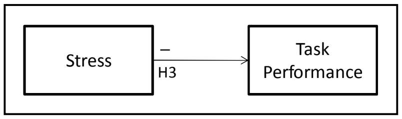

Figure 5.17 Hypothesis tested in Step 3

5.5.4.1 Perceptual Stress

Hypothesis 3 stated that individual stress is negatively related to task performance. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the negative direction as expected ($b = -3.123$, $F(1,119) = 4.410$, $p < 0.05$), implying that Hypothesis 3 was supported. The predicted value for task performance for low stress (one standard deviation below the mean) was 48.42, while the value for task performance for high stress (one standard deviation above the mean) was 42.71 (see Figure 5.18). Thus, perceptions of stress seem to have impacted participants' motivation to perform at a high level, resulting in lower task performance.

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[17] To additionally verify the appropriateness of averaging the measures, we conducted the analyses in Step 3 separately for the two stress scores for gray and red interruptions for perceptual and hormonal stress. Conducting these separate analyses did neither change the results for the perceived nor for the hormonal measure of stress.

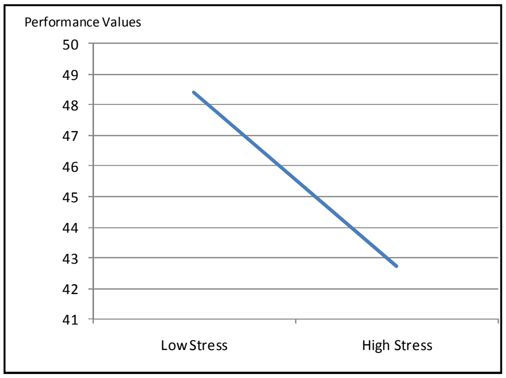


Figure 5.18 Task Performance for Low and High Levels of Perceived Stress

5.5.4.2 Salivary Alpha-Amylase

Hypothesis 3 stated that individual stress is negatively related to task performance. An RM-ANOVA was conducted to test this hypothesis. This ANOVA showed a significant relationship in the negative direction as expected ($b = -0.094$, $F(1,118) = 7.654$, $p < 0.05$), implying that Hypothesis 3 was supported. The predicted value for task performance for low stress (one standard deviation below the mean) was 44.74, while the value for task performance for high stress (one standard deviation above the mean) was 37.65 (see Figure 5.19). Hence, experiences of stress seem to have influenced participants' motivation, lowering performance.

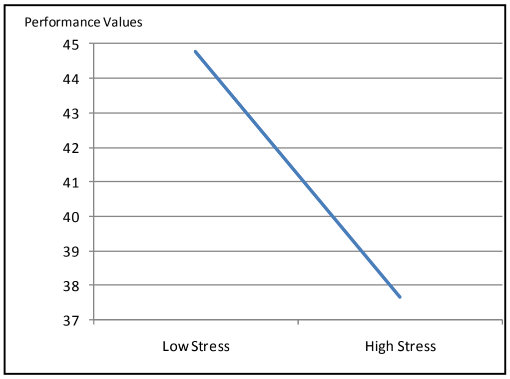


Figure 5.19 Task Performance for Low and High Levels of Hormonal Stress

5.5.5 STEP 4: THE MEDIATING ROLE OF MENTAL WORKLOAD

To evaluate the mediating role of mental workload, formal significance tests of the indirect effect were conducted using the Sobel script and the bootstrapping procedure developed by Preacher and Hayes (Preacher and Hayes, 2004). Below, we first report on the results for the perceptual measure of stress. Then, we report on the findings for stress measured through sAA.

5.5.5.1 Perceptual Stress

For perceptual stress, a significant z-value was found for the indirect effect, which was in the positive direction as expected ($b = 0.168$, $z = 1.967$, Std. Error = 0.085, $p < 0.05$) (MacKinnon et al., 2002; Sobel, 1982). The results further revealed that there was no direct effect of interruption frequency on stress when mental workload was controlled for ($p > 0.05$), indicating full mediation.

However, since the Sobel test tends to yield underpowered estimates of the intervening effect (Hayes, 2009; Preacher & Hayes, 2004), we conducted an additional analysis using the bootstrapping procedure developed by Preacher and Hayes (2004; 2008). This approach can be applied with greater confidence to small samples, and it is recommended over the Sobel test (Sobel, 1982) and the causal steps approach (Baron & Kenny, 1986) because it has more power while maintaining good control over the Type I error rate (MacKinnon et al., 2002; 2004). The bootstrapping procedure as a formal test of mediation is a nonparametric re-sampling technique involving repeated sampling from the sample data and estimating the indirect effect in all re-sampled data sets (Preacher &

Hayes, 2008). Consistent with the Sobel test, the results from this procedure exhibited a significant indirect effect (b = 0.168, Std. Error = 0.081, $p < 0.05$, no. of bootstrap re-samples = 5,000). Specifically, because zero was outside the 95% confidence interval (LL = 0.020, UL = 0.331), we can conclude with 95% confidence that the indirect effect between frequency and stress is different from zero.

Although Baron & Kenny's (1986) causal steps approach has recently been suggested to be less favorable than formal significance tests of the indirect effect, which more directly reflect the idea of mediation (MacKinnon et al., 2004; Preacher & Hayes, 2004), it deserves mentioning that mental workload also acted as a full mediator when using the causal steps approach (Step 2 of this approach was significant at the 0.05 level, Step 3 was significant at the 0.001 level). 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 as well as between the mediator and the dependent variable is significant (Kenny, et al., 1998; MacKinnon et al., 2002).

5.5.5.2 Salivary Alpha-Amylase

For sAA, a non-significant z-value was found for the indirect effect (b = 0.699, z = 0.626, Std. Error = 1.115, $p > 0.05$) (MacKinnon et al., 2002; Sobel, 1982). However, since the Sobel test tends to yield underpowered estimates of the intervening effect (Hayes, 2009; Preacher & Hayes, 2004), we conducted an additional analysis using the bootstrapping procedure (Preacher & Hayes, 2004; 2008). Consistent with the Sobel test, the results from this procedure failed to exhibit a significant indirect effect ($b = 0.699$, Std. Error = 1.143, $p > 0.05$, no. of bootstrap re-samples = 5,000). Specifically, because zero was inside the 95% confidence interval (LL = -1.014, UL = 3.499), we cannot conclude that the indirect effect between frequency and stress is different from zero.

5.5.6 STEP 5: THE MEDIATING ROLE OF STRESS

To assess the mediating role of individual stress, formal significance tests of the indirect effect were conducted using the Sobel script and the bootstrapping procedure developed by Preacher and Hayes (Preacher and Hayes, 2004). Below, we first report on the results for the perceptual measure of stress. Then, we report on the findings for stress measured through sAA.

5.5.6.1 Perceptual Stress

For perceptual stress, a significant z-value was found for the indirect effect, which was in the negative direction as expected ($b = -0.123$, $z = -2.554$, Std. Error = 0.048, $p < 0.05$) (Sobel, 1982). The results further revealed that there was no direct effect of mental workload on task performance when perceived stress was controlled for ($p > 0.05$), indicating full mediation.

Additionally, we conducted the bootstrapping procedure (Preacher & Hayes, 2004; 2008). Consistent with the Sobel test, the results from this procedure exhibited a significant indirect effect (b = -0.123, Std. Error = 0.049, $p < 0.05$, no. of bootstrap re-samples = 5,000). More specifically, because zero was outside the 95% confidence interval (LL = -0.225, UL = -0.034), we can conclude with 95% confidence that the indirect effect between mental workload perceptions and task performance is different from zero.

In addition, perceived stress also acted as a mediator when using the causal steps approach (Step 2 of this approach was significant at the 0.001 level, Step 3 was significant at the 0.01 level) (Baron & Kenny, 1986). 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 as well as between stress and performance was significant (Kenny, et al., 1998; MacKinnon et al., 2002).

5.5.6.2 Salivary Alpha-Amylase

For sAA, a non-significant z-value was found for the indirect effect (b = -0.024, z = -1.065, Std. Error = 0.022, $p > 0.05$) (MacKinnon et al., 2002; Sobel, 1982). However, since the Sobel test tends to yield underpowered estimates of the intervening effect (Hayes, 2009; Preacher & Hayes, 2004), we conducted an additional analysis using the bootstrapping procedure (Preacher & Hayes, 2004; 2008). Consistent with the Sobel test, the results from this procedure failed to exhibit a significant indirect effect (b = -0.024, Std. Error = 0.024, p > 0.05, no. of bootstrap re-samples = 5,000). More specifically, because zero was inside the 95% confidence interval (LL = -0.083, UL = 0.008), we cannot conclude that the indirect effect between mental workload perceptions and task performance was different from zero.

5.6 CHAPTER SUMMARY

This chapter reported the results from the data analysis. It described the development of the research instrument including the pre-test, the pilot-test, and the preliminary analyses. Only few changes were necessary in response to this preliminary instrument assessment since much care was taken during the initial design of the experiment. The chapter also assessed the quality of the measures and manipulations used in the experiment, including reliability, convergent validity, and discriminant validity. Then, it described the procedural remedies taken to reduce potential common method effects. Due to 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, common method variance was argued not to be an issue in this study. Statistical analysis confirmed this conclusion.

The research model was tested using a number of statistical techniques including RM-ANOVA, independent samples t-tests comparing older and younger participants, and formal tests of mediation (i.e., the Sobel test and the bootstrapping procedure). The results supported the majority of the hypotheses. More specifically, we found that interruption frequency gives rise to perceptions of mental workload, and that this relationship depends on inhibitory effectiveness and computer experience as hypothesized. We further found that older participants had lower levels of both inhibitory effectiveness and computer experience. Still, we did not find support for H10, the three-way interaction involving the frequency with which interruptions appear, their salience, and age. Potential reasons for this finding are explored in the next chapter.

Concerning stress, we found that perceptions of mental workload gave rise to stress perceptions and salivary alpha-amylase as expected, and that this stress effect depended on computer self-efficacy. It was also found that older participants had lower levels of computer self-efficacy as expected. Further, it was found that mental workload acted as a full mediator linking interruption frequency and perceived stress. However, such mediation was not found for the hormonal measure of stress. Finally, support was found for the relationship between stress and task performance. Perceptual stress was found to affect task performances as expected and to fully mediate the link between mental workload perceptions and performance. The relationship between stress and task performance was confirmed for the hormonal measure of stress; mediation, however, was not found for this measure. In summary, the full research model except for H10 was found to be supported; however, mediation could not be confirmed for salivary alpha-amylase (see Table 5.14 and Figure 5.20).

Analysis step	***Hypothesis Number***	***Statement***	***General Support***	***Support for Perceived Stress***	***Support for sAA***
1	1	The frequency of T-M interruptions is positively related to perceived mental workload.	✓	**n/a**	**n/a**
	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.	✓	**n/a**	**n/a**
	5	Older compared to younger people have lower levels of inhibitory effectiveness.	✓	**n/a**	**n/a**
	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.	✓	**n/a**	**n/a**
	7	Older compared to younger people have lower levels of computer experience.	✓	**n/a**	**n/a**
	10	The salience of T-M interruptions and age moderate the effect of the frequency of T-M interruptions on perceived mental workload so that differences in the effectiveness of the frequency of T-M interruptions on the basis of the salience of T-M interruptions are stronger for older compared to younger people.	☒	**n/a**	**n/a**
2	2	Perceived mental workload is positively related to individual stress.	**n/a**	✓	✓
	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.	**n/a**	✓	✓
	9	Older compared to younger people have lower levels of computer self-efficacy.	✓	**n/a**	**n/a**
3	3	Individual stress is negatively related to task performance.	**n/a**	✓	✓

Legend: the "***General Support***" category applies to all hypotheses that are not stress-related; n/a = not applicable.

Table 5.14 Summary of the Support Found for the Research Hypotheses

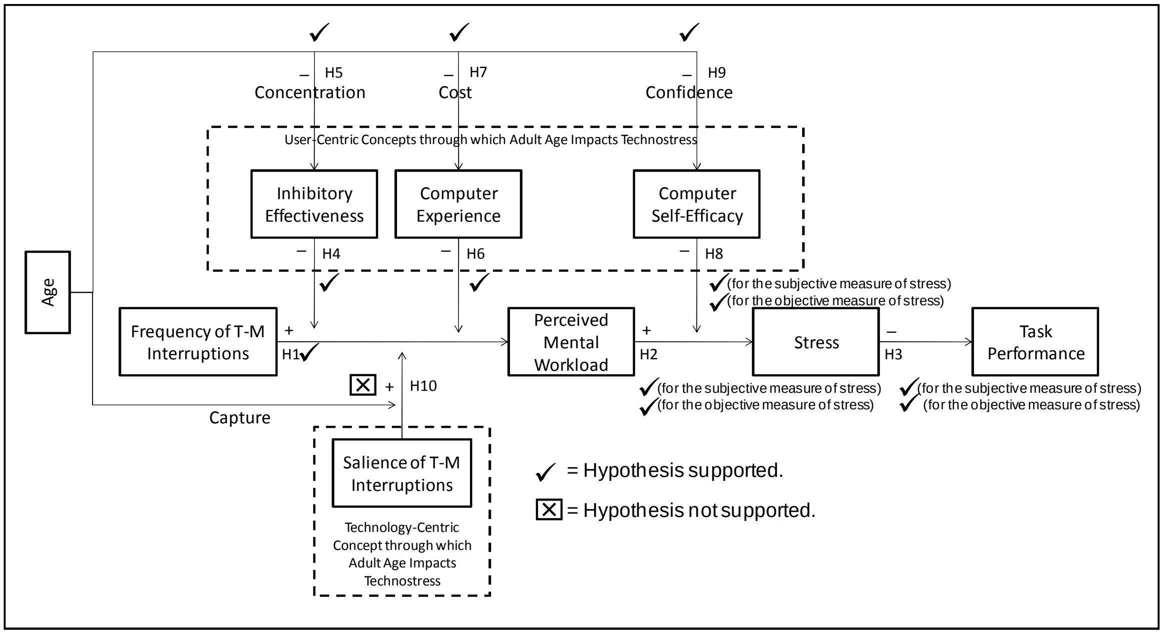


Figure 5.20 Summary of the Support Found for the Research Hypotheses

The next chapter discusses the results in more detail, offers implications for research and practice, and provides concluding thoughts.

Chapter Six: Discussion and Conclusion

6.1 INTRODUCTION

The findings of this study suggest that T-M interruptions affect stress and task performance indirectly through their impact on mental workload perceptions. They also indicate that older adults are more affected than younger since older people tend to have lower levels of inhibitory effectiveness, computer experience, and computer self-efficacy, all of which have been shown here to weaken the negative effects of T-M interruptions. However, these findings have to be interpreted in light of the limitations of this study, which are discussed next. The chapter then discusses the findings in greater detail, before offering implications for research and practice. Finally, the chapter provides directions for future research.

6.2 LIMITATIONS

Even though this research conducted an initial test on the model it formulated, further testing and refinement is necessary for a number of reasons. Most importantly, this research lacks ecological validity (i.e., real-world resemblance) since it used a stylized task to simulate mental demands in a laboratory setting. However, although the task and setting used in this research may not have real-world counterparts, 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). 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 memory task Concentration), the participants, and the measures to be consistent with much prior research in the areas of cognition and technostress (e.g., Baker-Ward & Ornstein, 1988; Basoglu & Fuller, 2007; Galluch, 2009; Washburn et al., 2007; Zacks & Hasher, 1997). Hence, the results of this study can probably be applied to various other environments, for example, hospital operating rooms.

Consider Ren et al.'s (2008) field experiment in which they examined interruptions and coping mechanisms in a hospital's operating room. They found that workload is a major problem in this environment and recommended the use of e-whiteboards to reduce the workload burden members of operating teams face. Since workload and cognition are important concepts in this complex and dynamic environment where individuals must process new situations continuously (Gonzalez, 2004; Ren et al., 2008) and since this study's results are rooted in cognitive theories such as person-environment fit theory (French et al., 1982; Pervin, 1968), the inhibitory deficit theory of cognitive aging (Hasher & Zacks, 1988), and social cognitive theory (Bandura, 1982), the psychological processes discovered here may well extend to such complex and dynamic contexts as operating rooms. Thus, evaluating the psychological processes proposed here in the context of operating rooms could help us understand the generalizability of this study's results and extend Ren et al.'s (2008) findings, potentially suggesting that the value of e-whiteboards may increase as teams include more older people.

Second, since our sample was limited to 128 participants, a Type II error was more likely to occur than in a larger sample. However, we effectively mitigated this concern through a number of strategies in our research design. Perhaps most importantly, we used a repeated measure design, allowing us to collect data for two experimental conditions from each participant. Moreover, we employed precise and reliable measures to reduce the amount of measurement error in our data, further improving statistical power. All alpha values exceeded the recommended guideline (Nunnally, 1978), and the reliabilities of the Nasa TLX and the Stroop color word task have been established by prior research (Cao et al., 2009; Shilling et al., 2002). Perhaps as a result of these strategies, the majority of our hypotheses were supported, allowing us to conclude that the sample size limit played an insignificant role in this research. Still, it should be kept in mind that the relationship posited for Hypothesis 10, which was not supported, may actually exist despite the results found here and that a study with a larger sample might find support for the relationship posited in it.

Third, our dichotomous experimental manipulations and selections may have limited our ability to fully understand the role of age in the technostress phenomenon. To maximize treatment variance, ascertain rigorous and precise distinctions in our experimental manipulations and selections, and increase the efficiency of our experimental design, we chose to use two opposed levels per factor (low and high). However, the use of two levels each for interruption frequency, salience, and age represents only two specific instances per factor, and it allows for examining only eight combinations of these factors. More information could perhaps result if one looked at more combinations of these factors. For example, future research could investigate the research model proposed here for middle-aged people. Such research could further increase the relevance of this study’s findings for organizations since middle-aged adults constitute a large part of the U.S. workforce. An initial response to this research objective is that the results found here would hold for middle-aged people since, for example, the relationships involving inhibitory effectiveness and interruption salience are considered to be linear (Darowski et al., 2008; Yantis & Egeth, 1999).

Fourth, only one technological stressor, the T-M interruption, was examined here. Hence, it is currently unclear how well the findings of this study may extend to other technological stressors such as constant connectivity, competitive pressures to keep using the latest technology, rapid technological change, and application crashes or lost data (Ragu-Nathan et al., 2008; Tarafdar et al., 2007). However, although these technological stressors are distinct, they are also similar in important ways (Ragu-Nathan et al., 2008), implying that the findings from this study may extend to them. More specifically, all these stressors are related to cognitive resources (Czaja et al., 2006; Ragu-Nathan et al., 2008), and can, hence, be viewed as belonging to the same group of technological stressors – cognitive resource-related stressors.

For example, constant connectivity often requires constant responses to email and other applications (Ragu-Nathan et al., 2008), implying that it demands a continuous stream of cognitive resources. Since this study’s findings are rooted in cognitive theories (Bandura, 1982; French et al., 1982; Hasher & Zacks, 1988; Pervin, 1968; Sweller, 1988;

1994), they may well extend to the phenomenon of constant connectivity. Similarly, the need to always use the latest technology, the rapid technological change, and application crashes or lost data imply the necessity to learn about the new technology and / or adapt to the new situation the new technology or application crash entails. Since individuals' ability to learn and adapt to new situations declines with age (Czaja et al., 2006), our general finding that older adults are more strongly affected by T-M interruptions may extend to these technological stressors as well. Hence, although focused on T-M interruptions, the study conducted here may offer valuable first insights into the role of age in technostress in general as it pertains to cognitive resources.

Finally, to clearly delineate the role of one specific facet of salience in the technostress phenomenon, only one operational definition of salience was used (i.e., interruption color). Other facets of salience, such as dynamism and aural alerts, may perhaps show stronger interaction effects with interruption frequency and age than color exhibited, potentially yielding full support for Hypothesis 10 that was not found here. Table 6.1 summarizes the limitations of this research.

Limitation	Relevance to this Research	Mitigation Strategy Used in this Research	Mitigation Strategy for Future Research
Ecological Validity	Use of a stylized task to simulate mental demands in a laboratory setting	(1) Implementation of incentive mechanisms to help increase the relevance of the task for the participants and the participant involvement	Same as the one in this research
		(2) Consistency with prior research in the areas of cognition and technostress	Same as the one in this research
Type II Error	The sample was limited to 128 participants	(1) Use of a Repeated Measure design	Same as the one in this research
		(2) Use of precise and reliable measures	Same as the one in this research
Limited Understanding of the Role of Age in Technostress	(1) Use of dichotomous experimental manipulations	Advancing the argument that employing middle groups for our factors is unlikely to yield more information	Use of more differentiated manipulations
	(2) Examination of only one Technological Stressor	Advancing the argument that the technological stressor examined in this study is similar to others belonging to the same group of stressors	Same as the one in this research
Limited Understanding of the Role of Salience in Technostress	Only one operational definition of salience was used	n/a	Use of more differentiated manipulations

n/a = not applicable

Table 6.1 Summary of the Limitations of this Research

6.3 DISCUSSION OF FINDINGS

The findings of this study extend prior research in the domains of technostress, attention, and cognitive aging, highlighting the complex links between technostress and the aging process. More specifically, a discussion of this study’s findings will improve understanding of (1) how and why T-M interruptions result in stress for individuals, (2) how and why interruptions may indirectly impact organizational productivity, and (3) whether, how, and why T-M interruptions affect older peoples’ stress responses along with their task performance differentially.

Figure 6.1, which guides the discussion of our findings, shows that this study has begun to open three important black boxes. It has begun to open the black box linking T-M interruptions and stress, the one linking stress and organizational productivity, and the one explaining how and why older people are differentially affected by T-M interruptions (this black box manifests at two links in the causal sequence from the interruptions to stress). The next sections elaborate on the disclosure of the content of these black boxes.

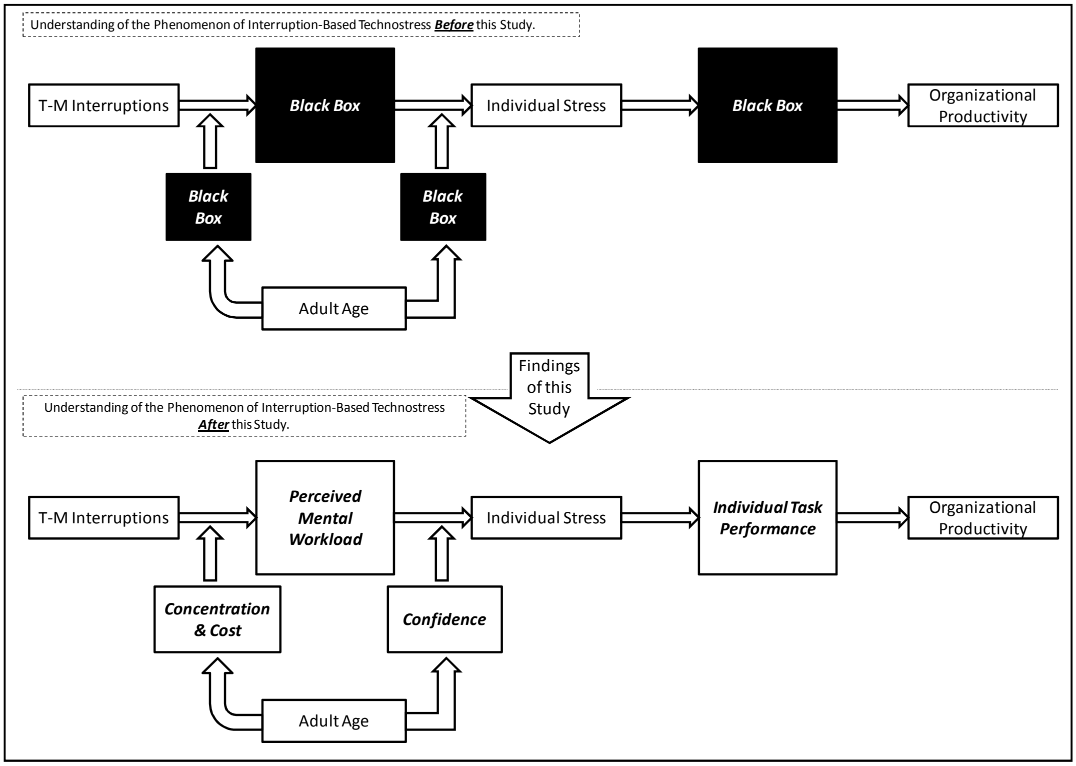


Figure 6.1 Findings of this Research

6.3.1 THE LINK BETWEEN T-M INTERRUPTIONS AND STRESS

Although prior research in the area of T-M interruptions is unclear on whether to model the effects of these interruptions on stress as direct or indirect, it converges on the idea that human cognition plays an important intervening role in the link between T-M interruptions and such interruption outcomes as individual stress (Basoglu & Fuller, 2007; Galluch, 2009; Ren et al., 2008). For example, prior research has argued that interruptions overload cognitive capacity and break peoples' concentration on a task (e.g., Basoglu & Fuller, 2007; Galluch, 2009). However, 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. This study extends this insight by using person-environment fit theory in conjunction with the selective attention framework to explain what cognitive resources are overloaded and why, and how and why peoples' concentration is broken.

This research has argued that the idea of human cognition as an intervening factor in the interruption – stress link is consistent with the P-E Fit perspective (Pervin, 1968; French et al., 1982), suggesting that T-M interruptions may affect stress indirectly through their impact on perceived P-E Misfit. More specifically, it has argued that the frequency with which T-M interruptions appear gives rise to mental workload (Hypothesis 1), which, in turn, affects individual stress (Hypothesis 2). This idea was supported for both perceptual and salivary measures of stress, although full mediation inferences are only justified for the perceptual measure of stress.

The intervening effect of mental workload suggests that individuals face difficulty managing the competing demands of task and interruptions for the limited capacity of working memory (Yeh & Wickens, 1988). Indeed, since the capacity of the storage component of working memory is strictly limited, sometimes to as little as one item at a time (Dumas & Hartman, 2008), an increasing frequency of T-M interruptions was shown in this study to draw working memory capacity away from the task at hand, resulting in a perceived misfit between working memory resource supply and demand.

Since computer-based tasks place particularly high mental demands on individuals (Birdi & Zapf, 1997), this person-environment misfit, in turn, created the threat of low performance (Endsley, 1995) and, thus, resulted in stress.

While perceived stress was found to be an indirect effect of T-M interruptions, resulting from perceptions of person-environment misfit, the same could not be clearly shown for the hormonal stress measure, potentially because hormonal measures have the disadvantage of representing very complex interactions with other systems in the human body and do not map well onto established psychological constructs (Schultheiss & Stanton, 2009). However, we were still able to confirm with this measure that the frequency with which T-M interruptions appear affects mental workload perceptions, which, in turn, impact individual stress. In so doing and explicitly using the selective attention framework and person-environment fit theory, we have begun to open the black box linking T-M interruptions and individual stress, proposing working memory as an important facet of cognition involved and revealing perceived mental workload, a form of person-environment misfit, as the connector between T-M interruptions and stress.

6.3.2 THE LINK BETWEEN STRESS AND PRODUCTIVITY

Although prior research in the area of T-M interruptions has stressed the negative implications of these interruptions for organizational productivity, it is unclear on how this organizational outcome arises. In fact, past research (Basoglu & Fuller, 2007; Galluch, 2009; Ren et al., 2008) has largely omitted the factors that could explain how T-M interruptions could manifest themselves in organizational outcomes. For example, Galluch (2009) has offered much insight as to whether T-M interruptions result in stress and what aspects of interruptions are stressful, but has not further examined the consequences of this interruption-based stress. However, if these interruptions and associated stress responses inhibit organizational productivity (Spira, 2005), it is critical to understand how they manifest themselves in this outcome.

The current research argues that the stress responses elicited by T-M interruptions affect individual task performance directly (Hypothesis 3) and, through this effect, may perhaps indirectly impact organizational outcomes. This idea was generally supported for both the perceptual and salivary measures of stress, both of which exhibited negative relationships with task performance. While this finding needs to be interpreted in light of the fact that organizational productivity was not included as an outcome variable in this study, it should be noted that the link between individual task performance and organizational productivity is established in the literature (Davis & Yi, 2004).

The relationship between individual stress and task performance found here suggests that interruption-based technostress may impact peoples' motivation to perform at a high level and may require them to devote a large amount of their limited energy to cope with the stressor rather than working on the task at hand, resulting in lower task performance (Beehr, 1995; Lord & Kanfer, 2002). Perceived stress may also result in reduced task performance because people reduce the effort they devote to a task in response to a perceived disequilibrium in an exchange relationship (Lord & Kanfer, 2002). Consistent with this concept, we found that perceived stress fully mediates the relationship between perceived mental workload, which is a disequilibrium perception, and individual task performance. Through this finding, we have begun to open the black box linking interruption-based technostress and organizational productivity, revealing task performance as a potential connector.

6.3.3 AGE-RELATED DIFFERENCES IN STRESS RESPONSES

Although 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 how and why such age effects should occur at all (see section 2.2.3), it converges on the idea that age has an important role to play (e.g., Czaja et al., 1998; Ragu-Nathan et al., 2008; Sharit et al., 1998). For example, Ragu-Nathan et al. (2008) found that technostress decreases with age, a finding inconsistent with their prediction, and explained this age effect with the simple notion that older people can perhaps deal better with stressors than younger because of their greater maturity. By contrast, Wang et al. (2008) found that technostress increases with age, however offering no explanation for this finding. Thus, more work is necessary in this area to improve understanding of whether technostress increases or decreases with age and how and why this age effect occurs. This study conceptualized and empirically tested a model specifying theory-driven points through which age touches on the technostress phenomenon. By consistently finding technostress to increase with age across several of these theory-driven age-related manifestations, this study begins to clarify the directionality of the age effect as well as how and why it occurs.

First, by employing the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988), this research has argued that older adults should be less able to inhibit attentional responses to T-M interruptions than younger people, implying that older adults benefit less from the moderating impact of inhibition on the link between interruption frequency and perceived mental workload (Hypotheses 4 and 5). This idea was supported since we found that (1) inhibitory effectiveness moderated the effect of the frequency of T-M interruptions on perceived mental workload so that the effect was weaker for higher levels of inhibitory effectiveness and that (2) older people exhibited lower levels of inhibitory effectiveness than younger.

The inhibitory deficit older people exhibited in accordance with Hypothesis 5 implies that they were less able to actively ignore the T-M interruptions and, consistent with Hypothesis 4, faced more trouble concentrating on the task at hand than younger people did when T-M interruptions appeared (Hasher & Zacks, 1988). As a result, interruptions were more likely to draw precious working memory resources away from the task at hand in older than in younger people, leading to higher perceptions of mental workload on the basis of T-M interruptions for older participants (Hasher & Zacks, 1988; Yeh & Wickens, 1988). By contrast, since younger participants were better able to actively disregard the interruptions, interference of interruptions with task-related processing was minimized, and younger adults were better able to focus their mental resources on the computer-based task (Hasher & Zacks, 1988).

By discovering older adults’ difficulty in inhibiting attentional responses to T-M interruptions as a moderating factor in the technostress process, we presented the first theory-driven explanation for differential responses to technological stressors across age groups, explaining *why* age matters in this phenomenon (Bacharach, 1989; Whetten, 1989). We term this age-related manifestation concentration. However, our analysis found that the black box linking adult age to technotress includes additional explanatory factors: computer experience and computer self-efficacy.

Computer experience emerged as a second point through which adult age touches on the technostress phenomenon. This research has argued that older adults should incur higher cost in terms of working memory resources than younger people when attending to T-M interruptions because older individuals should benefit less from the moderating impact of computer experience between interruption frequency and perceived mental workload (Hypotheses 6 and 7). This hypothesis was supported since we found that (1) computer experience moderated the effect of the frequency of T-M interruptions on perceived mental workload so that the effect was weaker for higher levels of computer experience and that (2) older people had lower levels of computer experience than younger as expected. As elaborated upon in Chapter 4, this conclusion is unlikely to be an artifact of our time. First, education as a major driver of computer experience will continue to be more accessible to younger than older people (National Science Foundation, 2010). Second, since the nature of ICTs will continue to evolve and change at a rapid rate (Benbasat & Zmud, 1999), older peoples’ mental models of how technology works will continuously be grounded in the past and, thus, will continuously be outdated and potentially incongruent with later technological developments, making them difficult to use.

The lower level of computer experience of older participants compared to younger implies, according to cognitive load theory (Sweller, 1988, 1994), that older people were relying on more resource-intense mental processes to do the computer-based task than younger people, who were relying on more efficient automatic processes. Cognitive load theory indicates that human memory consists of schemata that link related pieces of information and that experience refines and automates these schemata and, thus, reduces the cognitive resources required by a task (Sweller, 1988, 1994). The difference in the task requirements of mental resources between younger and older individuals along with the moderating impact of these requirements on the interruption frequency – mental workload link suggests that older participants incurred higher resource-related cost on the basis of T-M interruptions than younger people did. Interruptions were more likely to draw precious working memory resources away from the task at hand in older than in younger people (Lee et al., 2007; Liu et al., 2004), leading to higher perceptions of mental workload on the basis of T-M interruptions for older participants (Yeh & Wickens, 1988). By contrast, since younger participants had more working memory resources to spare for the processing of these interruptions, a smaller amount of mental resources was “stolen” from the processing of task-related content in younger compared to older adults, and younger people were better able process the T-M interruptions in addition to the content of the computer-based task.

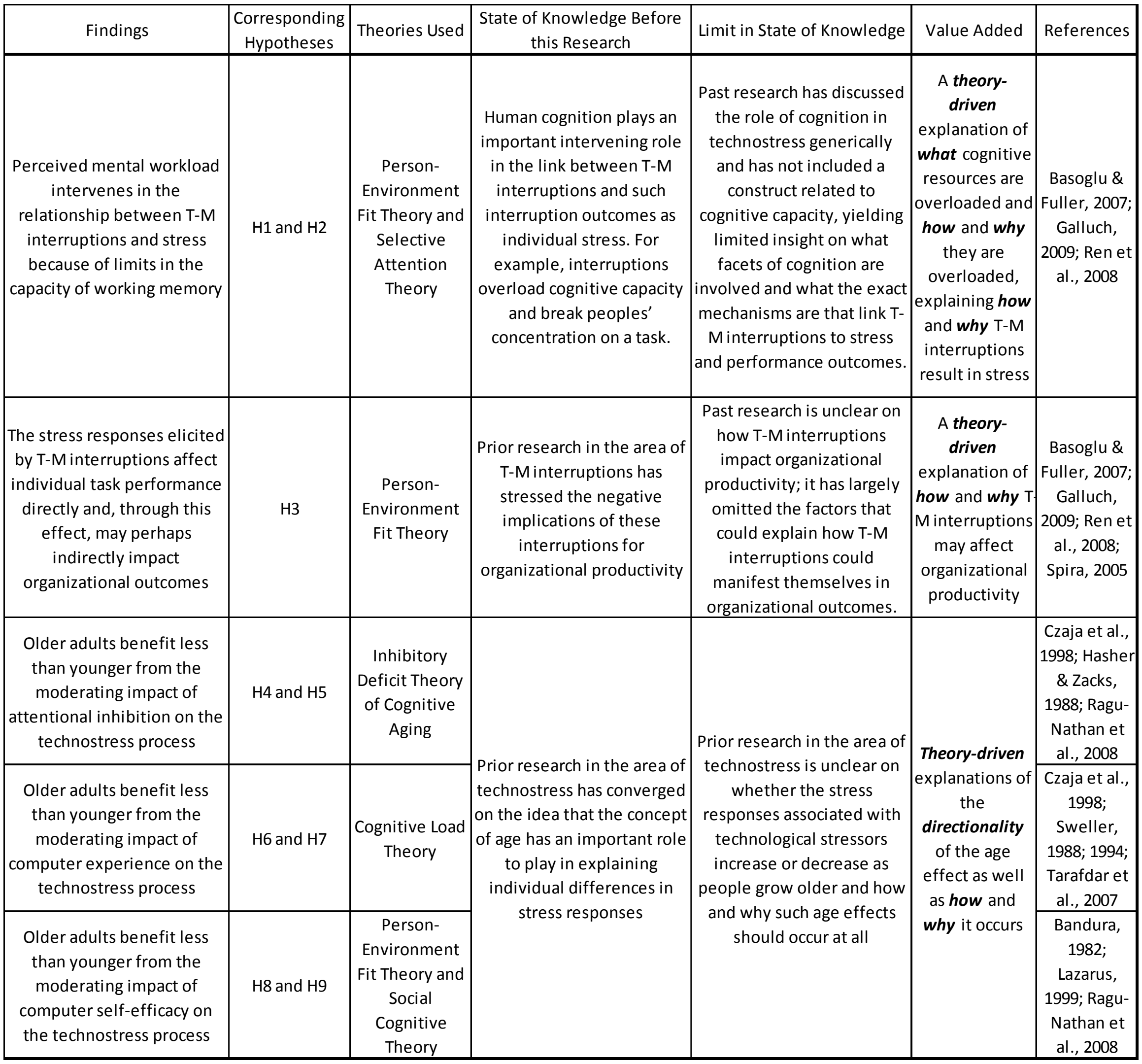
By discovering older adults' greater resource-related cost as a moderating factor in the technostress process, we posited a second explanation for differential responses to technological stressors across age groups. As with concentration, cost relates to working memory capacity since it concerns the amount of working memory people have to spare for the processing of interruptions (Sweller, 1988, 1994). Hence, both concentration and cost are consistent with prior research suggesting that human cognition is pertinent to the stress process. In addition, our analysis found that the black box linking adult age to technostress includes such other cognitive explanatory factors as computer self-efficacy.

Computer Self-efficacy (CSE) emerged as a third point through which adult age touches on the technostress phenomenon. The current research argues that older adults should have lower confidence regarding computer-use and should, therefore, benefit less from the moderating impact of CSE between perceived mental workload and individual stress (Hypotheses 8 and 9). This hypothesis was supported for both the perceptual and the salivary measures of stress. More specifically, we found that (1) CSE moderated the effect of mental workload perceptions on individual stress so that the effect was weaker for higher levels of CSE and that (2) older compared to younger people reported lower levels of CSE as expected.

The lower level of CSE of older compared to younger participants implies that older ones were less likely to maintain positive thoughts about their ability to successfully accomplish the computer-based task in the presence of substantial mental workload (Bandura, 1989; Lazarus, 1999). Hence, older participants had less opportunity to cope with excessive mental workload (a threat to task performance) than younger people and, thus, experienced higher levels of stress on the basis of mental workload perceptions. By contrast, since younger participants were better able to positively frame their interpretations of excessive mental demands, feelings of threat related to task performance were minimized, and younger adults were better able to deal with their mental workload perceptions (Bandura, 1989; Lazarus, 1999). Since CSE as the age-related manifestation referred to here as confidence deals with thinking processes and, as such, is rooted in human cognition (Bandura, 1982; 1989), our opening of the black box of age-related manifestations is entirely consistent with prior research on technostress suggesting that human cognition is relevant to the stress process (e.g., Basoglu & Fuller, 2007; Galluch, 2009; Ragu-Nathan et al., 2008; Tarafdar et al., 2007).

Concerning capture, our fourth age-related manifestation, this research has argued that interruption frequency should have stronger workload effects for more salient interruptions, particularly for older people (Hypothesis 10). This would imply that older adults are more affected by the impact salience exerts on the link between interruption frequency and perceived mental workload. However, we did not find support for this hypothesis. A plausible explanation relates to color as an aspect of salience. More specifically, differences in interruption color may perhaps not be sufficient to elicit differential attentional capture effects within and across age groups. It could be that other aspects of salience, for example, whether a message moves across the screen or appears with an aural alert, elicit stronger attentional capture effects and would show the anticipated patterns where color did not. While research on attentional capture effects (e.g., Strayer & Drews, 2007; Wickens et al., 2004) is silent on the issue of whether different facets of salience are differentially effective in capturing attention, exploring the effects of these other aspects of salience in the domain of technostress seems to be a viable avenue. This exploration may help to further our understanding of the role of salience in the technostress phenomenon and how salience interacts with age.

Another plausible explanation for the lack of support found for Hypothesis 10 relates to our use of a repeated measure design. While this design type was an efficient choice for this study, it may have increased our difficulty to find support for this hypothesis. More specifically, the error term may be larger in within-subjects than in between-subjects designs when one tests for the interaction between subjects and treatment, making it more difficult to reject the null hypothesis (Tabachnick & Fidell, 2007). Accordingly, had we used a between-subjects instead of a within-subjects design, we may have had more statistical power (Tabachnick & Fidell, 2007) and may have found Hypothesis 10 supported. Table 6.2 summarizes the findings of this study in terms of the value they add to research on technostress.



Findings	Corresponding Hypotheses	Theories Used	State of Knowledge Before this Research	Limit in State of Knowledge	Value Added	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	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.	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	Basoglu & Fuller, 2007; Galluch, 2009; Ren et al., 2008
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.	A ***theory-driven*** explanation of ***how*** and ***why*** T-M interruptions may affect organizational productivity	Basoglu & Fuller, 2007; Galluch, 2009; Ren et al., 2008; Spira, 2005
Older adults benefit less than younger from the moderating impact of attentional inhibition on the technostress process	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 how and why such age effects should occur at all	***Theory-driven*** explanations of the ***directionality*** of the age effect as well as ***how*** and ***why*** it occurs	Czaja et al., 1998; Hasher & Zacks, 1988; Ragu-Nathan et al., 2008
Older adults benefit less than younger from the moderating impact of computer experience on the technostress process	H6 and H7	Cognitive Load Theory				Czaja et al., 1998; Sweller, 1988; 1994; Tarafdar et al., 2007
Older adults benefit less than younger from the moderating impact of computer self-efficacy on the technostress process	H8 and H9	Person-Environment Fit Theory and Social Cognitive Theory				Bandura, 1982; Lazarus, 1999; Ragu-Nathan et al., 2008

Table 6.2 Value Added of this Research

6.4 IMPLICATIONS FOR RESEARCH

The following sections discuss this study's implications for information systems research and its reference disciplines. First, we detail important implications for the study of technostress. Next, we offer some significant methodological implications for IS research. Finally, we advance important implications for such pertinent reference disciplines as psychology.

6.4.1 IMPLICATIONS FOR RESEARCH ON TECHNOSTRESS

To discuss what the current study implies for research on technostress in terms of the role of age, the mental processes involved, the IT artifact, and coping abilities, we first place this study's findings in the broader nomological network of technostress. The dominant paradigm in the technostress domain holds that (1) technological stressors have direct, linear effects on stress, and that (2) such organizational interventions as social support, autonomy, and control directly reduce the presence of both technological stressors and stress (see Figure 6.2) (Ragu-Nathan et al., 2008; Tarafdar et al., 2010; Wang et al., 2008). The current research extends this dominant perspective in several important ways, indicating that information systems researchers need to think deeper about the nomological network of technostress (see Figure 6.3).

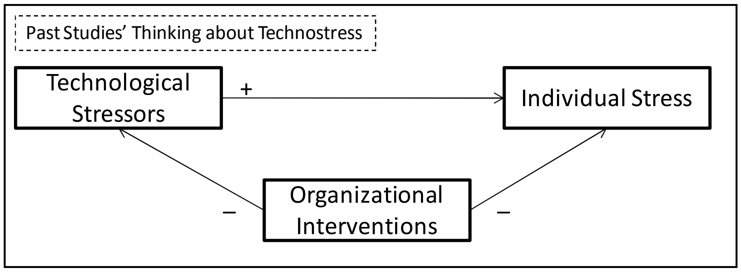


Figure 6.2 The Dominant Paradigm in the Technostress Domain

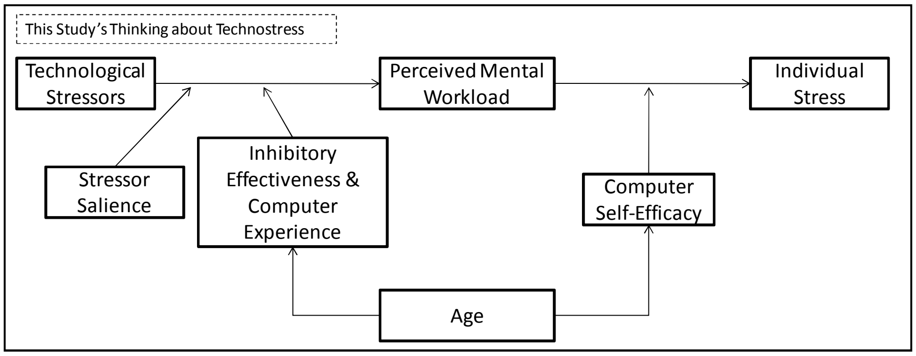


Figure 6.3 This Study's View of Technostress

The most important finding of this study is that age plays a significant role in the technostress phenomenon. The conceptualization proposed in this research extends prior work by advancing explicit theoretical arguments for the observed age differences. First, we used the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988), a major theory of cognitive aging, to suggest that older people suffer an inhibitory deficit and, therefore, experience more difficulty in ignoring interruptions. Second, we relied on Social Cognitive Theory (Bandura, 1982) in conjunction with Coping Theory (Lazarus, 1966) to argue that computer self-efficacy declines as people age and, thus, they become less able to cope with the P-E Misfit arising from technological stressors. Finally, we relied on the long tradition of research on domain-specific experience (Shiffrin & Schneider, 1977) as well as visual search and attentional amplification (Houghton & Tipper, 1994) to advance the argument that older people should react more strongly to interruption frequency and salience than younger.

By advancing these explicit theoretical arguments we went beyond the stereotypical arguments commonly made (e.g., greater resistance to change in older adults, Tu et al., 2005) and were able to find consistent age-related differences across several dimensions of cognitive aging. Where prior research often observed age-related differences in stress responses that ran counter to their expectations (e.g., Ragu-Nathan et al., 2008), we found support for the vast majority of our age-related hypotheses. Where the age-related implications offered in one prior study often contradicted those from 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, we found consistent evidence across the three age-related manifestations of concentration, cost, and confidence that older adults experience more technostress.

Furthermore, 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 prior research suggested that adult age simply acts 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, but rather manifests across the nomological network of technostress through the cognitive abilities associated with inhibitory control and computer experience and the thinking processes associated with computer self-efficacy. In so doing, we show that the concept of age yields a large set of potential anchor points for organizational intervention strategies.

In addition, we show that the role of age in the technostress phenomenon is more complex than commonly assumed. More specifically, prior research often proposed a linear effect of age on the technological stressor (e.g., Ragu-Nathan et al., 2008). We suggest that the role of age is more complex than a simple linear effect would suggest. In fact, we find that age impacts technostress largely in a non-linear 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, allowing us to specify the conditions under which age manifests rather than simply examining whether it manifests.

By theorizing about specific cognitive abilities and beliefs that link the concept of age to the technostress phenomenon, we also shed light on the exact mechanisms at play in connecting adult age to technostress. More specifically, we indicate that age-related differences in stress responses to technology exist due to age-related declines in inhibitory control (concentration), computer experience (cost), and computer self-efficacy (confidence). Importantly, these mechanisms' power to explain how and why age-related differences in technostress exist can be expected to continue into the future since all of these mechanisms are rooted in human cognition (Bandura, 1982; 1989; Hasher & Zacks, 1988; Sweller, 1988; 1994).

The mechanisms used here to explain age-related differences in technostress contribute to cumulative theory. The importance of contributing to cumulative IS theory has long been emphasized; for example, it enables the creation of stronger theories with greater explanatory power, and it increases research relevance (Keen, 1980; Banbasat & Zmud, 1999). While the concepts of inhibitory effectiveness and attentional amplification are new to IS scholarship, they are rooted in cognitive psychology research, which has long been applied to information systems research (e.g., Davis et al., 1989). More importantly, the study of computer experience and CSE has a long tradition in IS research (e.g., Harrison & Rainer, 1992; Compeau & Higgins, 1995), implying that the knowledge of the discipline regarding these concepts can now – by means of our extension – readily be applied to the study of technostress. For example, the field's knowledge of ways to increase peoples' computer experience and CSE can now be applied to help older adults incur less technostress.

The support found for our age-related hypotheses also implies that the dominant research paradigm of determining relevant technological stressors, their consequences, and organizational interventions is not sufficient by itself; it is also important to examine what differences exist across people that explain varying stress responses and how and why stress responses vary with these individual differences. Overall, the current study appears to have deepened our understanding of the role of age in the technostress phenomenon.

A second way in which the current research extends the dominant paradigm in the technostress domain is related to the nature of the relationship between the technological stressor and individual stress. We suggest that technology may not always cause stress directly as indicated by the dominant perspective, but may rather influence stress indirectly through its impact on such cognitive resources as working memory. In so doing, we moved beyond merely examining whether technology leads to individual stress to shed light on *how* technology impacts stress. This extension indicates that technostress research is progressing from the investigation of general associations between variables to more detailed and specific explanations of the causal pathways through which technology impacts stress (MacKinnon & Luecken, 2008). This more detailed understanding is not only of theoretical interest, but has practical significance for the development of effective organizational interventions as well.

Third, the dominant perspective models the effects of technological stressors on stress as linear, implying that the stressors will have to be removed in order to limit their detrimental impacts on individuals and organizations. In contrast to this perspective, we show that technological stressors may have non-linear effects on stress, suggesting that technology may cause stress through its interaction with cognitive abilities and beliefs. This implies that technology in and of itself does not have the “dark side” of causing stress, and that organizations may not have to remove or change technology to reduce its detrimental impacts; instead, organizations can take actions aimed at impacting individuals’ cognitive abilities and beliefs so that technology becomes less likely to cause stress.

Fourth, the research presented here implies that it may be important to theorize about specific groups of technological stressors, for example, cognitive resource-related stressors (e.g., T-M interruptions, constant connectivity) or anxiety-related stressors (e.g., technological insecurity, technological complexity) (Tarafdar et al., 2007), in isolation rather than aggregating several of these types into an overall stressor as done by prior research (e.g., Tarafdar et al. 2007; Ragu-Nathan et al., 2008, Tarafdar et al., 2010). This implication is consistent with the trajectories of related domains in information systems research, such as the trajectory of research on post-adoptive technology use. The latter suggests that taking a feature-centric view is critical to understanding post-adoptive use since, for example, some features are more important than others (Jasperson et al., 2005). In line with this trajectory, an aggregate measure of technostress may obscure the stress implications of specific facets of technology from an empirical viewpoint. For instance, such resource-related stressors as constant connectivity may perhaps be highly stressful, while such anxiety-related stressors as technological insecurity may perhaps have little influence on stress. When evaluated as a whole, constant connectivity may appear to have merely a moderate impact on stress, when perhaps different aspects of technology have conflicting implications for stress.

From a conceptual viewpoint, theorizing about specific groups of technology rather than aggregate constructs can result in more detailed explanations and a deeper understanding of the causal pathways involved in the stress process (Jasperson et al., 2005). For example, the research reported here was able to use strong theoretical frames such as Person-Environment Fit theory and the Inhibitory Deficit Theory of Cognitive Aging since it was purposefully limited to the domain of cognitive resource-related stressors, more specifically, the T-M interruption. Focusing on this particular facet of technology allowed us to be very specific about the causal pathways involved in the stress process and the reasons behind age-related differences in technostress, where an aggregate construct may have obscured these specifics. For instance, the Inhibitory Deficit Theory of Cognitive Aging appears to explain age-related differences in interruption-based technostress more effectively than age-related differences in stress related to technological insecurity, an anxiety-related stressor that does not as tightly fit the idea of inhibiting attentional responses to distracting stimuli. Accordingly, it appears to be vital for technostress research to be specific about the IT artifact so that the specific cognitive mechanisms involved in the stress process can be isolated.

A related extension of technostress research is our positioning of technology as both a driver and magnifier of stress. As a driver, technology can enhance an individual's mental workload perceptions, leading to technostress. This finding supports existing perspectives on how people experience technostress (e.g., Ragu-Nathan et al., 2008; Tarafdar et al., 2010). When conceptualized as a magnifier, specific ICT features (e.g., color, dynamism, aural alerts) may perhaps create synergies with other technological stressors and may, thereby, generate negative individual and organizational impacts above and beyond the commonly modeled direct and linear effects of technological stressors. While research has yet to support this idea empirically, perhaps by using a larger sample size, the idea may still help us think about whether different aspects of technology can interact in the stress process and how specific ICT features may complement other technological stressors in generating technostress.

Finally, this research suggests that individuals can leverage their technology-related belief systems to cope with the feelings of threat arising from technological stressors, a concept not previously considered in the literature. More specifically, we found that peoples' belief systems regarding successful computer use (i.e., CSE) interact with their perceptions of person-environment misfit to cause stress, shedding light on a mechanism that can readily help people deal more effectively with the feelings of threat arising from person-environment misfit. This finding also implies that the role of CSE in the technostress phenomenon is more complex than commonly assumed. For example, Ragu-Nathan et al. (2008) proposed a simple direct effect of CSE on such technological stressors as technological complexity. We show that CSE plays a more important role; it helps people cope. As such, CSE enables individuals to manage high levels of person-environment misfit effectively (Lazarus & Folkman, 1984) by weakening the threat-involving thoughts arising from them (Lazarus, 1999). In so doing, CSE not only serves as a mechanism that simply explains whether people experience stress but it also allows us to understand *for whom* person-environment misfit results in stress, yielding a “more sophisticated” understanding of the interdependencies in the stress process (MacKinnon & Luecken, 2008, p. S99). This finding is consistent with prior research suggesting that extending control to individuals about whether to take a break can weaken experiences of technostress (Galluch, 2009). Combined, these studies indicate that coping is an integral part of the technostress process that should complement any study of technostress.

Figure 6.4 abstracts from this study’s view of technostress to offer a general extension of the dominant paradigm. In this abstraction, we suggest on the basis of our age-related findings that individual difference variables may play an important role in the technostress phenomenon by explaining the differences in technostress responses across people. Such individual difference variables may include gender, education, or any other variable related to peoples’ beliefs, goals, and personal resources (Lazarus, 1999; Venkatesh et al., 2003). The importance of incorporating individual difference variables into an extended view of technostress can also be inferred from Kurt Lewin (1946, p. 794), who eloquently wrote consistent with Lazarus (1966; 1999):

“The problems of general laws and of individual differences frequently appear to be unrelated questions which follow somewhat opposite lines. Any prediction, however, presupposes a consideration of both types of questions; problems of individual differences and of general laws are closely interwoven. A (scientific) law is expressed in an equation which relates certain variables. Individual differences have to be conceived of as various specific values which these variations have in a particular case. In other words, general laws and individual differences are merely two aspects of one problem; they are mutually dependent on each other and the study of one cannot proceed without the study of the other."

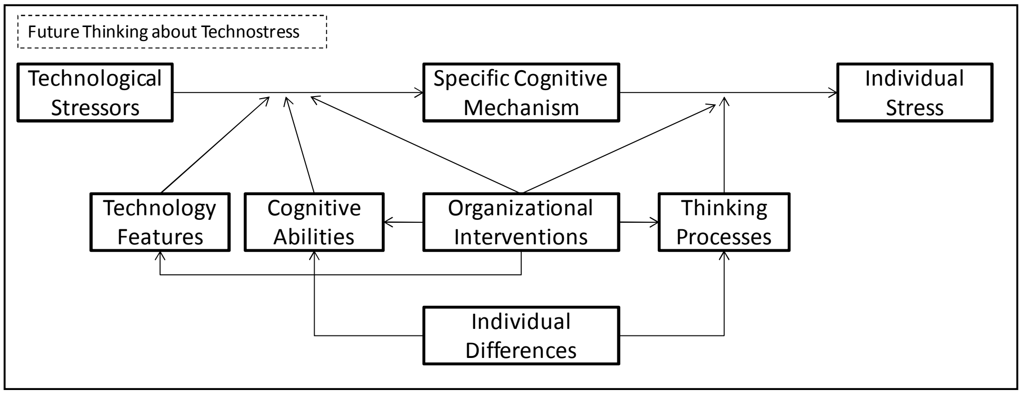


Figure 6.4 Extended View of Technostress

In our general extension of the dominant paradigm we also suggest on the basis of our salience, inhibitory effectiveness/computer experience, and CSE-related conceptualizations and/or findings that technology features, cognitive abilities, and thinking processes, respectively, may play important roles in the technostress process. As argued earlier, technology features may explain synergistic effects between technological stressors, while cognitive abilities may explain under what conditions technological stressors become overwhelming and thinking processes can explain how people cope with technological stressors. Importantly, the specific types of technology features (e.g., salience, complexity), cognitive abilities (e.g., attentional responses, fluid intelligence), and thinking processes (e.g., self-efficacy, learned resourcefulness) (Lazarus, 1999) studied have to be closely tied to the specific technological stressors under examination, aiding conceptual and empirical advances in this area as argued earlier. Also, managerial interventions need to be explicitly modeled within this extended view to deepen understanding of how technology features, cognitive abilities, and thinking processes can be influenced so that the consequences of technological stressors are minimized.

6.4.2 IMPLICATIONS FOR THE IT ARTIFACT

This research demonstrates for IS scholars that the nature of technology is multifaceted with respect to the forms technology can take. More specifically, we demonstrate that such different forms of the IT artifact as the Tool type (e.g., interruption frequency, color, dynamism, aural nature) and the Proxy type (e.g., computer experience, computer self-efficacy) (Orlokowski & Iacono, 2001) can effectively be combined in a single study and can, in fact, interact (e.g., interruption frequency, a tool, was shown here to interact with computer experience, a proxy). By demonstrating that the effectiveness of IT as a tool can depend on the effectiveness of IT as a proxy, we articulate the initial idea that interdependencies exist among different forms of the IT artifact. This demonstration can help IS scholars to develop exceptionally rich theories in terms of an explicit treatment of technology, yielding rich technology-related findings. Since the IT artifact is central to IS phenomena (Orlikowski & Iacono, 2001; Benbasat & Zmud, 2003), such richness can help the IS community to make strong contributions to the understanding of today’s technological world and to preserve a central identity[18]. This is particularly true

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[18] We recognize that other scholars (e.g., Agarwal & Lucas, 2005; Lyytinen & King, 2004) expressed other opinions concerning the identity of the IS field. However, we refrain from engaging in this debate here.

since we focused on such forms of the IT artifact in which IT is actually present as opposed to absent (Orlikowski & Iacono, 2001).

6.4.3 METHODOLOGICAL IMPLICATIONS FOR IS RESEARCH

This study demonstrates for IS researchers that game-like computerized tasks are an effective alternative to the spreadsheet-like artificial tasks commonly used in experimental information systems research (e.g., Yi & Davis, 2003). While game-like computerized tasks have regularly been employed in psychology research on cognitive functioning (e.g., Baker-Ward & Ornstein 1988; Schumann-Hengsteler 1996; Washburn et al 2007), their use in IS research is nascent. We are aware of only one prior IS study that has employed a game-like computerized task: Dabbish and Kraut (2008) used the Jumpers video game, which is a variation of the classical “Jump and Run” game, to study the coordination of communication between distributed co-workers. This lack of use of game-like computerized tasks in experimental IS research is surprising since such tasks are intrinsically motivating and provide continuity and context for responding (Washburn, 2003). As a result, the participants may stay engaged over the long durations required by experiments, taking the experimental task seriously and keeping focused on it. These implications are desirable for experimental IS research, effectively reducing method effects and the likelihood of misleading results.

Second, we demonstrate for IS researchers that repeated measure experimental designs can be effective for research involving information systems phenomena, suggesting that this type of design deserves more attention from IS scholars. Indeed, a comprehensive search across all issues published by *MIS Quarterly*, *Information Systems Research*, and the *Journal of Management Information Systems* since their inceptions using such keywords as “Repeated Measure” revealed only a limited number of studies that used this design type for conducting laboratory experiments (Biocca et al., 2007; Dennis & Kinney, 1998; Jiang & Benbasat, 2007; Kahai & Cooper, 1999; Kopcso et al., 1988; Roberts et al., 2005; Suh & Lee, 2005; Tam & Ho, 2006). This is surprising since repeated measure designs allow experimental studies to be conducted with a high degree of efficiency. Specifically, repeated measures designs require fewer participants since all subjects participate in more than one condition, implying that time and monetary resources devoted to participant recruitment are minimized. This efficient use of recruitment-related resources leaves more time and research funds for follow-up studies. More importantly, the experiment can be conducted more quickly since fewer groups of people are needed to complete the study. Given the rapid technological change along with the field’s need for relevance (Benbasat & Zmud, 1999), faster study completion times are valuable for IS research in that they reduce the time-to-market of information systems-related knowledge.

However, IS researchers may need to consider that repeated measure designs, while efficient, may not be the most effective choice of research design for testing the interaction between subjects and treatment. As mentioned earlier, the error term may be larger in this case for within-subjects than between-subjects designs, implying a conservative statistical test with relatively little statistical power (Tabachnick & Fidell, 2007). Still, it is important to note that the statistical test is not inappropriate since the

Type I error rate is not affected, but detecting a significant difference can be more difficult (Tabachnick & Fidell, 2007). Hence, when evaluating the usefulness of different design types for their particular studies, IS researchers need to consider that our design choice might have been the reason of why we did not find support for Hypothesis 10.

Third, the study presented here extends past research suggesting that such "objective" measures as salivary alpha-amylase are superior to perceptual measures (e.g., Galluch, 2009). Specifically, the mixed support found here for formal mediation indicates that seemingly objective measures are not always more effective and valid than perceptual measures. While there are indeed such threats to the validity of perceptual measures as biases, there are also threats to the validity of such "objective" measures as salivary alpha-amylase. For example, increases in the alpha-amylase hormone can readily be understood as an indicator of stress. However, hormone levels also increase, for instance, after a meal, and the alpha-amylase hormone also changes in response to alcohol consumption as well as other non-stress related activities (while people often consume alcohol in response to perceptions of stress, alcohol in and of itself is not known to cause stress). While these aspects can readily be controlled for, it appears that the alpha-amylase hormone is only partly indicative of peoples' stress responses and that its functions in the human organism encompass more than just stress (Schultheiss & Stanton, 2009). In addition, the multiplicity of interactions of hormonal systems with one another as well as with the body immune system, the peripheral organs, and the brain systems are often complex (Schultheiss & Stanton, 2009), making it difficult to isolate, for example, hormonal changes due to stress. Nevertheless, the use of such hormonal measures as alpha-amylase can yield much insight (Granger et al., 2007).

The question of what type of measure is preferable may depend on the specific study, its research objective, and the reference disciplines that inform it. For example, consistent with prior research in the area of technostress, the current study was primarily informed by cognitive psychology. Hence, a perceptual measure of stress was an effective choice since it can be expected to correlate with other facets of cognition. Still, the hormonal measure of stress was an effective addition since certain relationships this study proposed, for example, the relationship between age and inhibitory effectiveness, were additionally informed by neurobiology. Hence, while the nature of the study may be an important aspect to consider when judging the value of “subjective” and “objective” measures in information systems research, the combination of both subjective (e.g., cognitive) and objective (e.g., hormonal) elements in a single study to develop a comprehensively justified conceptual model and a triangulated research design may yield the most valid and insightful results.

Finally, this research demonstrates for IS researchers that older people are well able to complete survey instruments on the computer. No problems related to the computer-based instrument were reported by the older participants or observed by the investigator. This finding implies that information systems research involving older people to uncover age-related differences in technology use can be conducted with a high degree of efficiency, further reducing the time-to-market of information systems-related knowledge.

6.4.4 IMPLICATIONS FOR REFERENCES DISCIPLINES

The study presented here has an important implication for psychology research since it appears to be one of the first to apply hypothetico-deductive logic to the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988) in its entirety, resulting in a robust and insightful explanation of how and why older adults should incur greater mental workload perceptions on the basis of T-M interruptions. To the best of our knowledge, the theory and its constructs had limited use in predictive variance models before. Psychology research has merely developed the theory to understand age-related differences in cognition in general and has, more recently, conducted a few correlational analyses to gain a better understanding of related concepts (e.g., Darowski et al., 2008) but has seldom used the concept in predictive models to explain age-related differences in important psychological phenomena, such as individual stress or performance in operating motor vehicles.

By demonstrating to psychology scholars that the theory as well as its constructs and measures yield strong potential to predict variables of interest and explain relationships in causal models, this study contributes to psychologists’ understanding of the theory by suggesting that it should more frequently be applied to help us understand important phenomena from an age-related perspective. For example, human factors psychology research on driving performance could use the theory to examine how such distractions along the road as advertisement signs exert differential impacts on younger and older drivers. As an initial response to this objective, one could suggest that older peoples' driving performance should be more affected by the signs, which can be expected to draw more working memory resources away from the driving task in older than in younger people (Hasher & Zacks, 1988). Hence, applying the inhibitory deficit theory to this context could yield interesting insights for human factors research, potentially suggesting that fewer advertisement signs should be placed along the road as the society is aging, and that the renewal cycle for driving licenses should be shortened.

The current research also has an important contribution to make to organizational stress research. It shows that the Person Environment Fit perspective (Pervin, 1968; French et al., 1982) can readily be integrated with theories of individual differences, such as the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988). While the P-E Fit perspective has long been recognized for acknowledging individual differences (e.g., Blau, 1981), we are unaware of any study but the one reported here that purposefully used this perspective to examine the impact of individual differences on a particular phenomenon and integrated the perspective with an important individual difference theory. Hence, this research laid the ground for integrating the P-E Fit perspective with a variety of other individual difference theories to gain deeper insights into individual differences in stress responses.

6.5 IMPLICATIONS FOR PRACTICE

This study examined the consequences of ICT use for individuals and – by extension – for organizations. Hence, the practical significance of this work is not trivial, particularly with the changing landscape of technology, for example, the emergence of Web 2.0 and IPv6. With Web 2.0, social contacts in general and social networking in particular gain further importance, implying that we have just seen the beginning of the infusion of such T-M interruptions as instant messages into peoples' personal and work lives. The future may be even more interruption-intensive. Accordingly, when investing in Web 2.0 to enter niche markets or co-create products with suppliers and customers, companies are well-advised to take the (potentially ever-increasing) cost of workplace interruptions into account and to develop company-specific strategies to reduce such cost. Depending on the number of older people in an organization, the strategies to counter these cost could focus on the age-related manifestations discovered here.

With IPv6, which replaces IPv4, an internet protocol address can have four times as many bits as before. In addition, IPv6 enables more efficient routing of packages since the packet header is simpler than the IPv4 header and since IPv6 routers do not carry out fragmentation. Accordingly, IPv6 allows for a much larger number of devices on and users of the internet. This conclusion implies that IPv6 enables an increase of peoples' dependence on a multitude of technological devices that constantly beep and buzz and beg for their attention. This is particularly true since the more efficient routing method of IPv6 may allow for even shorter message delivery times than was possible with IPv4.

Most importantly, detrimental impacts on employee stress and performance may arise from the interaction of Web 2.0 and IPv6. Since Web 2.0 motivates a large number of interconnected devices and users and IPv6 enables such interconnection, we may enter a new interruption era. For example, motivated by the Web 2.0 spirit and enabled by the IPv6 technology, the social networking site Facebook has just launched a group messaging and video messaging initiative in the Summer of 2011, furthering the likelihood of T-M interruptions to occur. Hence, managers may be well-advised to counter the threats to organizational productivity arising from T-M interruptions by leveraging the findings of this research. According to the IT Interaction Model (Silver et al., 1995), this research has implications for firm strategy, business processes, organizational structure, and IT infrastructure, since it examined the consequences of ICT use for individuals and – by extension – for organizations.

Concerning firm strategy, business processes, and organizational structure, companies may be well advised to adjust corporate policies and cultural norms regulating T-M interruptions in the workplace since these interruptions have been estimated to generate annual cost in excess of 500 billion U.S. dollars in the U.S. alone (Spira, 2005). First, change management may be necessary to ensure that fewer messages with the potential to interrupt are exchanged. For example, employees could be asked to send an instant message only when the subject matter requires instant attention. They may further be asked to send only particularly urgent instant messages to older employees. Second, policies and cultural norms requiring employees to respond instantly to newly appearing messages could be relaxed, allowing them to finish their tasks before reading and responding to incoming messages.

Concerning IT infrastructure (which includes training and user attributes, Silver et al., 1995), managers should consider investing in computer training to address the adverse effects of T-M interruptions on employee performance since it can simultaneously increase computer experience (Thompson et al., 1994; Tomporowski, 2003) and computer self-efficacy (Marakas et al., 1998; Yi & Davis, 2003), both of which were shown in this study to weaken the negative effects of T-M interruptions. In serving this dual role, user training may provide an efficient avenue for managers to help employees, particularly older ones, handle stressful encounters with T-M interruptions. More specifically, by exposing individuals to technology and thereby increasing their experience with it, computer training enables people to use ICTs with reduced mental effort. As a result, users have more resources for the processing of T-M interruptions and, hence, incur a weaker person-environment misfit from them. At the same time, training builds users' perceptions of their ability to use the computer successfully in support of their work tasks. Hence, people will be less likely to feel threatened by any potentially arising misfit with their work environment on the basis of T-M interruptions. However, training programs need to be tailored to different age groups since learning differences across age groups are relevant for computer training (Van Fleet & Antell, 2002). For example, older adults require approximately twice as much time as younger individuals to learn computer-related skills and complete computer training tasks (Morris et al., 2005).

Managers may also benefit from learning how to accommodate older employees' differential vulnerability regarding interruption frequency. Consistent with prior research in the technostress context suggesting that managers need to assign employees to tasks consistent with their individual traits (Chilton et al., 2005), this research indicates that managers may be well advised to design jobs for older individuals such that they are better able to manage T-M interruptions. For example, jobs for older people could be designed so that they do not depend on a multitude of technological devices that constantly beep and buzz, helping older employees to perform their primary tasks more effectively. Similarly, workstations for older employees could be designed in such a way that they are given particularly easy access to customizing whether, when, and how interruptions appear, further helping older people to work more effectively.

However, we would like to emphasize that this research does not imply that older adults are less adequate employees than younger. Instead, we hold that job redesign could help organizations leverage older peoples' differential skills. More specifically, while the greater vulnerability in older individuals to T-M interruptions resulted in lower task performance in the short-run, it may benefit them and their respective organizations in the long-run. Recent research has shown that initially distracting information can lead to superior long-term performance in older adults compared to younger when the initially distracting information becomes relevant at a later time (Kim et al., 2007). Hence, if organizations would re-assign older employees to technology-related positions that emphasize long-term instead of short-term performance, they may find that older people are a highly valuable human resource even in today's technological world.

Concerning systems design, designers may need to improve the ease of use of their systems for older individuals since ease of use is a major antecedent to computer experience (Czaja et al., 2006; Hawthorn, 2007). Such an improvement could increase older individuals' mental capacity for processing interruptions, reducing their experiences of technostress on computer-based tasks.

To improve ease of system use for older individuals, systems designers may need to involve older adults often and early in the design process since there tends to be a large gap between younger designers and older users (Newell et al., 2006). Designers often assume a similarity with the user, an assumption that is not accurate for older users. Involving older people early in the design process could help bridge this age gap, ensuring that older people are not overwhelmed by the interrupting nature of technology. For example, systems designers could more often test their systems on populations reflective of the actual users rather than on convenience samples as commonly done (Jeng, 2005). Since older adults are underrepresented in the U.S. workforce in general (U.S. Bureau of Labor Statistics, 2008) and in systems design-related jobs in particular (U.S. Bureau of Labor Statistics, 2010), and since they tend to travel a lot (Bai et al., 1999), accessing them for usability testing may be relatively inconvenient. Hence, older people may be underrepresented in software usability testing, implying that software is not designed with them in mind. To improve this situation, systems designers may need to refrain from convenience sampling, particularly for systems that are important for older individuals (e.g., health information systems).

To further assist older adults handle T-M interruptions as effectively as younger people do, systems designers should consider to design different types of interruptions in such a way that all these types appear in the same (i.e., fixed) location as opposed to different locations on the screen. Research has shown that predictability of spatial location substantially counteracts the disadvantage older people have in inhibiting attentional responses to distracting stimuli, allowing them to inhibit almost as effectively as younger (Carlson et al., 1995). For example, in the current version of Skype (i.e., 4.2.0.169), incoming VoIP phone calls and instant messages, which can be considered different types of T-M interruptions, appear in different locations on the screen. While VoIP phone calls appear in the center of the screen, instant messages appear in the task bar on the bottom of the screen. If Skype were re-designed such that both types appeared in the task bar, older individuals would be helped in inhibiting an immediate attentional response to either interruption type.

6.6 FUTURE RESEARCH

We advance a research agenda consisting of five research streams that we believe are worthy of the attention of IS scholars. As shown in Figure 6.5, which guides the discussion of these five streams, the current state of knowledge concerning the role of age in IS phenomena is limited, and so is the current state of knowledge concerning technostress. First, as pointed out in our literature review, IS research on aging is largely atheoretical (e.g., Lam & Lee, 2006; Morris & Venkatesh, 2000; Morris et al., 2005). Since theory is important to deepen understanding of why certain relationships exist (Bacharach, 1989; Whetten, 1989), we suggest in Stream 1 that more theory-driven IS research on age should be conducted, and we advance specific examples for how such research could unfold. Second, although this study has begun to clarify the role of age in technostress, much remains to be learned. Hence, we recommend in Stream 2 that future research should investigate additional age-related manifestations not examined here so that a comprehensive understanding of the role of age in technostress can be attained. Third, past behavioral IS studies on technostress (e.g., Ragu-Nathan et al., 2008; Tarafdar et al., 2007; 2010) have not taken a feature-centric view on technological stressors and have, thus, offered limited insight as to how technology should be designed so that technostress is reduced. Hence, we suggest in Stream 3 that future research should translate behavioral research results into design decisions so that behavioral and design-oriented IS research interact synergistically (see Hevner et al., 2004, for a detailed discussion of the benefits of such a synergistic relationship), reducing technostress.

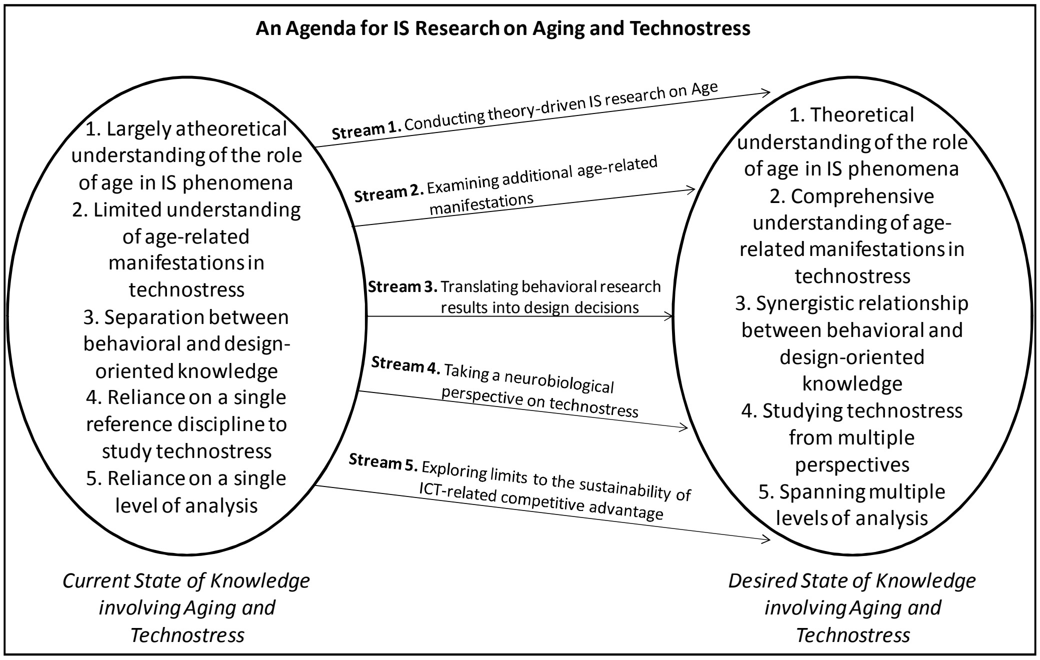

Figure 6.5 An Agenda for Future Research

Fourth, past studies (e.g., Ragu-Nathan et al., 2008; Tarafdar et al., 2007; 2010) and this study have largely relied on psychology as the only reference discipline to deepen understanding of the technostress phenomenon. Based on the results of this study as well as prior studies concerning hormonal measures of stress (Galluch, 2009), we suggest in Stream 4 that future research should explore the technostress phenomenon from a neurobiological perspective to help us understand the technostress phenomenon from multiple complementary viewpoints, perhaps yielding a unified theory of technostress once these perspectives are integrated. Such a comprehensive and unified theory could yield ample explanatory power (Kuhn, 1970). Finally, past studies (e.g., Ragu-Nathan et al., 2008; Tarafdar et al., 2007; 2010) and this study have primarily used the individual level of analysis to examine technostress, yielding insight as to how technological stressors impact people. To leverage this insight for an understanding of the organizational consequences of technostress, we suggest in Stream 5 that future research should span multiple levels of analysis. More specifically, we suggest that future research may benefit from exploring the limit technostress may impose on the sustainability of ICT-related competitive advantage.

6.6.1 STREAM 1: CONDUCTING THEORY-DRIVEN IS RESEARCH ON AGE

This research has used the Inhibitory Deficit Theory of Cognitive Aging (Hasher & Zacks, 1988) and has dug deep into Social Cognitive Theory (Bandura, 1982) as well as research on domain-specific experience (e.g., Liu et al., 2004) to advance its theoretical arguments concerning age-related manifestations. Perhaps as a result, most of its age-related hypotheses were supported. By contrast, many prior studies have superficially included the concept of age in their research models and, perhaps as a result, often did not find support for the proposed age-related differences (e.g., Ragu-Nathan et al., 2008; Tu et al., 2005). This contrast suggests that well-developed theoretical arguments for the relationships involving age are helpful in understanding the role age plays in the phenomena studied by information systems researchers. Future research should more thoroughly explore theoretical frames with the potential to explain the role of adult age in the phenomenon of interest. For example, the concept of fluid intelligence used in this research to argue for the role of CSE as an age-related manifestation can perhaps be applied more broadly to the study of post-adoptive technology use. Given that peoples' ability to learn and adapt to new situations (i.e., fluid intelligence) declines with age (Czaja et al., 2006) and given that learning and adaptation are critical in the post-adoption context (Cooper & Zmud, 1990; Jasperson et al., 2005), older people may differ in their post-adoptive behaviors from younger because of declines in fluid intelligence. This analysis suggests that using the concept of fluid intelligence in post-adoption research is more likely to yield interesting insights and accurate results than if one superficially "threw" the concept of aging into the model.

This analysis could be used to extend, for example, the study conducted by Ahuja & Thatcher (2005). The authors suggested that autonomy and overload affect trying to innovate, and that gender moderates these relationships. According to the logic presented above, age could be an additional important moderator in this model. The positive relationship between autonomy and trying to innovate could be weaker for older adults since they may be less likely to leverage their autonomy for engaging in something they experience as more difficult. In other words, the freedom to innovate could matter less for older people due to their potentially greater personal impediments to innovation behaviors. By contrast, the negative relationship between overload and trying to innovate could be stronger for older compared to younger people since overload may reduce individuals’ capacity to learn, and this reduction could be particularly detrimental for people with already low learning abilities.

6.6.2 STREAM 2: EXAMINING OTHER AGE-RELATED MANIFESTATIONS

To discover age-related manifestations in technostress not considered here, future research could combine the concept of fluid intelligence discussed earlier with relevant technology-related traits. For example, the concept of fluid intelligence could be combined with personal innovativeness in information technology (PIIT), which refers to the extent to which individuals are willing to try out any new information technology (Agarwal & Prasad, 1998), to examine whether PIIT may serve as an additional age-related manifestation. As peoples’ ability to learn and adapt to new situations declines with age (Czaja et al., 2006), they should experience more difficulty learning about and adapting to new information technologies. This difficulty may decrease the willingness of older individuals to try out new technology since difficulty to use a technology generally reduces peoples’ intentions to use it (Venkatesh et al., 2003). This analysis combined with PIIT’s strong relationship with computer anxiety (Thatcher & Perrewe, 2002) suggests that PIIT may serve as another relevant age-related manifestation in the technostress phenomenon. Future research could further explore this initial idea.

6.6.3 STREAM 3: LINKING BEHAVIORAL AND DESIGN-ORIENTED RESEARCH

To help reduce technostress, results of behavioral technostress research could be used to inform ICT-related design decisions. For example, future research could, on the basis of this study, examine how to design interfaces so that the burden on working memory is minimized. If interfaces are developed such that they require a minimum of working memory capacity, they leave more capacity for attending to T-M interruptions, reducing the negative impacts of these interruptions on employee well-being and performance. For example, recent research indicates that paging requires less working memory resources than page scrolling does (Wickens et al., 2004), leaving more resources for attending to interruptions and reducing the negative side effects of these interruptions. This logic raises the question of what other mechanisms systems designers can leverage to reduce the working memory burden associated with technology interfaces such that individuals can attend to interruptions with a reduced detrimental impact for their well-being and performance.

6.6.4 STREAM 4: A NEUROBIOLOGICAL PERSPECTIVE ON TECHNOSTRESS

Based on prior research this study has primarily taken a cognitive perspective to understand how T-M interruptions result in individual stress as well as how and why older adults should be differentially affected. Still, it has complemented this perspective with concepts from neurobiology where applicable, for example, to inform the relationship between age and inhibitory effectiveness. Future research could extend this study by taking a more comprehensive neurobiological perspective on the processes involved. In fact, the finding that T-M interruptions affect mental workload perceptions, which, in turn, impact salivary alpha-amylase, suggests that neurobiological processes may be important drivers linking interruptions and individual stress.

Further, the non-significant correlation (r = 0.00) between the perceptual and hormonal measures of stress discovered here warrants further research. The correlation had a p-value of 1.00, implying that no evidence at all was found here to support an association between the two measures. This finding may suggest that there were essential differences between the two measures (e.g., the perceptual and hormonal measures may have assessed different aspects of stress). Given the superiority sometimes attributed to physiological measures in terms of objectivity (e.g., Galluch, 2009), this null-relationship raises two interrelated questions: (1) are physiological measures, in fact, more objective than psychological measures? and (2) should IS research use physiological measures as substitutes for perceptual measures to lend more credibility to its findings?

While physiological measures may have the advantage of greater reliability, they may be less valid than perceptual measures. More specifically, perceptual measures can often be biased (e.g., common method variance, desirability bias), and hence unreliable, whereas physiological measures lend themselves to a pre-post design[19]. However, as mentioned before, the alpha-amylase hormone is only partly indicative of peoples' stress

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[19] For example, if participants enter a research laboratory with a cold, they may have an unusual alpha-amylase level due to the interaction of the alpha-amylase hormone with the body immune system (Schultheiss & Stanton, 2009). However, if the pre-condition hormonal level is controlled for in the analysis, this interaction's potential to bias the results should be effectively reduced. Such a pre-post design may be more difficult to implement using perceptual measures, which often directly relate to experiences concerning specific events and, hence, cannot as readily be evaluated prior to the event.

responses, its functions in the human organism encompassing more than just stress (Schultheiss & Stanton, 2009). This aspect points to a disadvantage regarding construct validity, especially since there is a multiplicity of complex interactions of hormonal systems with one another as well as with the body immune system, the peripheral organs, and the brain systems (Schultheiss & Stanton, 2009). Furthermore, established guidelines currently exist for assessing the validity of perceptual measures, while the validity of physiological measures cannot as readily be evaluated, further suggesting that physiological measures may not be superior in terms of valid measurement. Additionally, physiological measures are often more narrowly focused (Bommer et al., 1995), implying potential issues with content validity. Hence, even if physiological measures may have less measurement error, it is important to remember that imperfectly measuring something relevant may be more meaningful than perfectly measuring something irrelevant (Cook & Campbell, 1979).

As an initial response to the question of whether IS research should use physiological measures as substitutes for perceptual ones to lend more credibility to its findings, one could first point to the validity problems of physiological measures, suggesting that these are not necessarily better than self-reported measures. More importantly, the differences found here between perceptual and hormonal stress suggest that these measures do not act as substitutes. For them to act as substitutes, physiology and psychology would have to have the same functions in the human organism. However, physiology relates to the human body, while psychology relates to the human mind, implying that psychological and physiological measures may not measure the same thing.

Instead, the two measures may have a positively synergistic relationship. Specifically, people can neither exist with a body nor with a mind alone; both are necessary to enable long-term survival. Hence, one of these components is of limited value without the other, pointing to a complementary rather than substitute relationship (Milgrom & Roberts, 1995). Thus, one measure alone may miss an important part of the picture.

This analysis is consistent with much prior research, which has frequently discovered low correlations between psychological and physiological measures, suggesting that substituting one for the other means substituting “apples for oranges” (Rich et al., 1999, p. 42). In fact, much prior research points to the complementary rather than interchangeable nature of physiological (or “objective”) and psychological (or “subjective”) measures (e.g., Cowen et al., 2007; Forth & McNabb, 2008; Rich et al., 1999). Thus, given that each type of measure has its own advantages and disadvantages, some researchers suggest that it would be prudent to trust those findings the most that were supported by both types of measures (Forth & McNabb, 2008). In fact, some even suggest that the use of both objective and subjective measures in the same study as was done here constitutes important scientific progress (Katona, 1976). If using both measures together is not possible in future research, the type to use should be carefully selected on the basis of the research objectives. Specific to the study reported here, future research could also examine how cognitive and neurobiological factors interact in causing stress, potentially yielding much insight into technostress (Kuhn, 1970).

6.6.5 STREAM 5: LIMITS TO THE SUSTAINABILITY OF COMPETITIVE ADV.

By uncovering pertinent conditions (e.g., age) under which technology can result in negative outcomes, this study could imply that certain aspects of technology (e.g., interruptions) may counter the sustained competitive advantage arising from other aspects of technology (e.g., knowledge sharing), a conclusion not previously considered in the literature. According to the resource-based view of the firm, sustained competitive advantage can be achieved when an organization possesses factors (e.g., resources, capabilities) that are valuable, heterogeneously distributed across competing firms, and causally ambiguous (i.e., they cannot be unambiguously connected to the competitive advantage) (Barney, 1991; Mata et al., 1995). The opposite may also be true; if certain factors diminish organizational value, are heterogeneously distributed across competing firms, and cannot be unambiguously connected to the value reduction they cause, they can perhaps counter any potential sustained competitive advantage arising from other factors. As pointed out by Wade and Hulland (2004), technology creates sustainability primarily through its interaction with other organizational factors, such as human resources, since factor interactions are likely to be heterogeneously distributed and causally ambiguous. T-M interruptions may fit this pattern: they reduce organizational productivity (Spira, 2005) and their interaction with particularly vulnerable employees may be heterogeneously distributed across competing firms and may make it difficult to link them to negative organizational outcomes. Hence, T-M interruptions may perhaps counter the sustained competitive advantage arising from other aspects of technology.

However, T-M interruptions occur at the individual-level, raising the question of how they should affect sustainability. We suggest that T-M interruptions can be conceptualized as affecting organizational capabilities since the latter are built from lower level routines, which are performed by groups of individuals (Salvato & Rerup, 2010). Routines, in turn, are the "organizational analogue" of such individual characteristics as skills, and they are stored in the procedural memory of individuals (Salvato & Rerup, 2010, p. 474). This implies that capabilities and routines can be understood as sequences of individual acts (e.g., sending an instant message). For example, Salvato (2009) investigated the link between individuals' daily actions and the evolution of a company's new product development capability. He was able to conceptualize this capability as a sequence of individual-level events by tracing its evolution to the acts of people. This analysis implies that we can conceptualize capabilities as being built from organizational routines, which are, in turn, understood as sequences of individual-level actions performed at specific times in specific settings by specific people (Salvato & Rerup, 2010). In summary, capabilities are continuously shaped by the actions of individuals, implying a strong linkage between individual-level actions and organizational capabilities (Salvato & Rerup, 2010).

This analysis can perhaps be applied to the context of technology, implying that certain technology-involving actions performed by specific individuals at specific times and places may affect technology-dependent capabilities. For instance, knowledge collaboration capabilities (KC) have been shown to depend on technology for communication purposes (Jarvenpaa & Majchrzak, 2008), where individuals collaborate via such technologies as instant messages. In this case, technology enables a firm to better leverage its KC capability (both dependence and leverage engender moderation arguments), leading to sustained competitive advantage if this interaction between the technology and the KC capability is valuable, heterogeneously distributed across competing firms, and causally ambiguous (Wade & Hulland, 2004).

However, while employees are using the technology to collaborate, they are also interrupted by it, resulting in stress and performance problems. Thus, such technology as instant messages may disrupt KC routines and, in turn, reduce the effectiveness of a firm's KC capability. In so doing, T-M interruptions may reduce the value of the KC capability. This may be particularly true if older employees are interrupted as shown in this research. Accordingly, if a firm combined a large number of interrupting technologies with a large number of older workers, a factor interaction arises that may counter the sustained competitive advantage arising from the collaborative aspects of the technologies. Future research may support this initial idea.

6.7 FUTURE RELEVANCE OF T-M INTERRUPTIONS

For T-M interruptions to remain relevant for practice and future research, they would have to continue to be a common problem to employee well-being and performance. For example, if employees could simply deactivate or disregard their technological devices, T-M interruptions would be unlikely to occur and would be of little relevance. However, good reasons exist to believe that these interruptions will be at least as relevant, if not more, to employee well-being and performance in the future as they were in the past. These reasons are fivefold: (1) the attention economy, (2) mandatory usage of technology, (3) peoples' technological identities, (4) new technological developments, and (5) the importance of cognitive surplus. First, in today's information economy, individuals' attention is a scarce resource that organizations are battling for (Davenport and Beck, 2001). As the U.S. economy is moving from an information to a knowledge economy, the importance of capturing peoples' attention may increase even further since knowledge can be considered a richer form of information (Davenport & Prusak, 2000), implying that more attentional resources may be required for its processing. Hence, the battle for peoples' attention may just have begun, while at the same time the number and complexity of interruptions mediated through technology appears likely to increase in the future.

Second, technology usage in contemporary organizations is often mandatory, implying that employees are not allowed to deactivate their interrupting devices. Especially in growing industries where technology can reduce the detrimental effects of errors, such as the healthcare industry, mandatory use of technology is becoming highly prevalent (Hennington et al., 2009). This situation is particularly true as organizations recognize the potential of technology to increase the quality of their goods and services while simultaneously reducing the costs of producing and delivering these goods and services. Moreover, as technical devices are becoming more interconnected, mandatory usage is further reinforced (Saeed et al., 2010). Hence, mandatory usage has been and will likely remain a common policy in organizations, implying that employees cannot simply withdraw from the interrupting nature of technology by deactivating it.

Third, recent research has shown that individuals can attribute meaning to technology and feel emotionally connected to it (Carter et al., 2011), potentially because technology is relevant to peoples' self-concepts; technology can either deviate from or support identities (Tripsas, 2009). In so doing, technology may challenge or reinforce peoples' concepts of who they are, resulting in dependence on the technology to form identities, particularly true if people have been using technology from early on in their lives at a time where their identities are formed most strongly. Accordingly, in today's environment where people are becoming increasingly familiar with technologies early in their lives, they also become increasingly dependent on it (Carter et al., 2011). This trend implies that individuals may increasingly face difficulty deactivating their technologies since such deactivation may negatively affect their sense of well-being, suggesting that T-M interruptions will remain relevant in the future as employees – even if allowed – may voluntarily choose not to deactivate their ICTs.

Fourth, T-M interruptions may remain relevant due to the changing landscape of technology, for example, due to the emergence of Web 2.0 and IPv6 as argued before, where negative impacts on employee stress and performance may arise from the interaction of these two technologies. Since Web 2.0 motivates a large number of interconnected technological devices as well as interconnected users and since IPv6 enables such interconnection, the era of T-M interruptions may just have begun.

Finally, such resources as cognitive surplus can be important drivers of such major workplace objectives as creativity (Amabile, 1998). Without this resource, people neither have the capacity for creative work, which often requires the exploration of new concepts and the development of unique solutions, nor do they feel that such work is valued. A recent example of creative tasks demanding this resource is Wikipedia, the online encyclopedia (Kirby, 2010). Since creativity is becoming ever more important in today's and tomorrow's information and knowledge economies and has just recently become one of the primary management concerns (Amabile & Khaire, 2008), it becomes increasingly important for IS scholars to understand the detrimental impacts of T-M interruptions on cognitive surplus.

6.8 CONCLUSION

Considering the aging of the U.S. workforce alongside the proliferation of technology, it appears imperative to develop a deeper understanding of the mechanisms that connect adult age to the technostress process. This study conceptualized and tested a research model that extends prior work in the area of age-related differences in technostress. Although a few prior studies included the concept of age in their models, they often did so on the basis of limited theoretical development, resulting in conflicting findings. Using pertinent theories of stress and cognitive aging, this study suggested, and for the most part found, that age-related differences in technostress manifest through the mechanisms of concentration, cost, confidence, and capture, which we referred to as our 4 C's. In so doing, 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 use technology more easily and effectively.

Appendices

APPENDIX A: SURVEY ITEMS FOR SUBSTANTIVE VARIABLES

Please answer the following questions. All of your answers will be treated confidentially. Any published document regarding these answers will not identify individuals with their answers. Thank you very much for your help!

For each of the statements below, please indicate your level of experience in working with computers:

On average, how frequently do you use a computer for communicating with others (for example, through e-mail, instant messages, Facebook)?

* Once a year or less
* Several times a year
* Several times a month
* Several times a week
* Several times a day

On average, how frequently do you use Internet browsers such as Mozilla FireFox, Internet Explorer and Google Chrome?

* Once a year or less
* Several times a year
* Several times a month
* Several times a week
* Several times a day

Overall, how frequently do you use a computer?

* Once a year or less
* Several times a year
* Several times a month
* Several times a week
* Several times a day

For each of the statements below, please indicate your level of confidence in working with a new and unfamiliar computer application, that is, a software package you have never used before:

I could complete a job using the computer if there was no one around to tell me what to do as I go.

* Not at all confident
* Not very confident
* Somewhat unconfident

- Moderately Confident
- Somewhat confident
- Very confident
- Totally confident

I could complete a job using the computer if I had never used a package like it before.

- Not at all confident
- Not very confident
- Somewhat unconfident
- Moderately Confident
- Somewhat confident
- Very confident
- Totally confident

I could complete a job using the computer if I had only the software manuals for reference.

- Not at all confident
- Not very confident
- Somewhat unconfident
- Moderately Confident
- Somewhat confident
- Very confident
- Totally confident

I could complete a job using the computer if I had seen someone else using it before trying it myself.

- Not at all confident
- Not very confident
- Somewhat unconfident
- Moderately Confident
- Somewhat confident
- Very confident
- Totally confident

I could complete a job using the computer if I could call someone for help if I got stuck.

- Not at all confident
- Not very confident
- Somewhat unconfident
- Moderately Confident
- Somewhat confident
- Very confident
- Totally confident

I could complete a job using the computer if someone else had helped me get started.
* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident
* Somewhat confident
* Very confident
* Totally confident

I could complete a job using the computer if I had a lot of time to complete the job for which the software was provided.
* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident
* Somewhat confident
* Very confident
* Totally confident

I could complete a job using the computer if I had just the built-in help facility for assistance.
* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident
* Somewhat confident
* Very confident
* Totally confident

I could complete a job using the computer if someone showed me how to do it first.
* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident
* Somewhat confident
* Very confident
* Totally confident

I could complete a job using the computer if I had used similar software packages before this one to do the same job.
* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident

* Somewhat confident
* Very confident
* Totally confident

Please indicate the extent to which you agree or disagree with the following statements describing your level of stress felt in consequence of working on the memory task:

I felt emotionally drained from working on the memory task.

* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

I felt used up from the task demands.

* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

I felt stressed from the task demands.

* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

I felt burned out from working on the memory task.

* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

I felt strain from the task demands.
    * Strongly Disagree
    * Disagree
    * Somewhat Disagree
    * Neither Agree Nor Disagree
    * Somewhat Agree
    * Agree
    * Strongly Agree

APPENDIX B: SURVEY ITEMS FOR CONTROL VARIABLES AND MANIPULATION CHECKS

Please answer the following questions. All of your answers will be treated confidentially. Any published document regarding these answers will not identify individuals with their answers. Thank you very much for your help!

Please indicate the extent to which you agree or disagree with the following statements describing the frequency of the interruptions that appeared during the memory task you just did:

Interruptions appeared very frequently during the task.
* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

There was an abundance of interruptions over the course of the task.
* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

Please indicate the extent to which you agree or disagree with the following statements describing the salience of the interruptions that appeared during the memory task you just did:

The interruptions seemed to "pop out" of the computer display.
* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

The interruptions stood out from the other information on the computer display.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree
   * Strongly Agree

Compared to other information on the computer display, the interruptions had a very unique appearance.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree
   * Strongly Agree

The interruptions were very effective in attracting my attention.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree
   * Strongly Agree

The interruptions very effectively grabbed my attention.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree
   * Strongly Agree

The interruptions very effectively captured my attention.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree

   * Strongly Agree

The interruptions were very noticeable.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree
   * Strongly Agree

The interruptions were very eye-catching.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree
   * Strongly Agree

For each of the statements below, please indicate your level of experience in playing the memory game called Concentration or Memory:

I have frequently played the memory game Concentration/Memory.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree
   * Strongly Agree

I have played the memory game Concentration/Memory a lot.
   * Strongly Disagree
   * Disagree
   * Somewhat Disagree
   * Neither Agree Nor Disagree
   * Somewhat Agree
   * Agree
   * Strongly Agree

I have often played the memory game Concentration/Memory.

* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

I have experience with the memory game Concentration/Memory.

* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

On average, how frequently have you played the memory game Concentration/Memory?

* Once a year or less
* Several times a year
* Several times a month
* Several times a week
* Several times a day

For each of the statements below, please indicate your level of confidence in playing the memory game called Concentration or Memory:

I believe I have the ability to describe how to play the memory game Concentration/Memory.

* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident
* Somewhat confident
* Very confident
* Totally confident

I believe I have the ability to excel in the memory game Concentration/Memory.

* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident

* Somewhat confident
* Very confident
* Totally confident

I believe I have the ability to be successful at the memory game Concentration/Memory.

* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident
* Somewhat confident
* Very confident
* Totally confident

I believe I have the ability to perform well in the memory game Concentration/Memory.

* Not at all confident
* Not very confident
* Somewhat unconfident
* Moderately Confident
* Somewhat confident
* Very confident
* Totally confident

For each of the statements below, please indicate how much you agree or disagree:

The interruptions were very distracting.

* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

The interruptions were very taxing.

* Strongly Disagree
* Disagree
* Somewhat Disagree
* Neither Agree Nor Disagree
* Somewhat Agree
* Agree
* Strongly Agree

The interruptions were very demanding.

- * Strongly Disagree
- * Disagree
- * Somewhat Disagree
- * Neither Agree Nor Disagree
- * Somewhat Agree
- * Agree
- * Strongly Agree

Related Questions

How many years of education did you complete?

- * No formal education
- * Less than high school graduate
- * High school graduate/GED
- * Vocational training
- * Some college/Associate’s degree
- * College graduate
- * Master's degree (or other post-graduate training)
- * Doctoral degree (PhD, MD, EdD, DDS, JD, etc)

How often do you typically engage in MENTAL activities such as playing mentally demanding games (for example, crossword puzzles, checkers, Sudoku, chess, etc.)?

- * Once a year or less
- * Several times a year
- * Several times a month
- * Several times a week
- * Several times a day

How often do you typically engage in PHYSICAL activities such as running, swimming, jogging, or other types of sports?

- * Once a year or less
- * Several times a year
- * Several times a month
- * Several times a week
- * Several times a day

APPENDIX C: VERBAL INSTRUCTIONS PROVIDED FOR EXPERIMENTAL TASKS

CONCENTRATION MEMORY TASK

The task involves that you find matching pairs of symbols by flipping computer-generated cards. In the process, you have to memorize the symbols you have seen and where the symbols are hidden. In this game, we will use arithmetic rather than the commonly used pictures. One card contains an integer number, and another matching card contains a multiplication that yields this integer number. For example, a matching pair of cards could consist of one card reading “30” and another card reading “5 times 6.” Your goal is to find as many matching pairs as possible within six minutes. After six minutes, the game window will automatically close. Since your goal is to find as many matching pairs as possible within six minutes, you must pay close attention. Let’s go through an example so you know what to expect.

As you can see, I click on the “Start Game” button to start a game. The cards are presented face down to you, and you alternately flip two cards for every move. In case the two uncovered cards do not match, both cards are returned to their face down position. Once you detect a matching pair of cards, the cards are left in a face up position. Importantly, the task does not end once all eight matching pairs are uncovered. Instead, if you uncover all eight matching pairs before six minutes are up, another matrix of cards will automatically appear. Once a new matrix of cards appears you go ahead and solve that one. Let me show you. Again, the goal is not to solve a single matrix, the goal is to uncover as many matching pairs as possible within six minutes. The game ends for you when the window in which you play closes automatically. Now, let me show you how exactly this works.

You move the mouse over the card you want to flip and click the left mouse button once. Then, you uncover a second card the same way by moving the mouse over the card and clicking the left mouse button once. If the cards match, they are left in a face up position. If the two cards don't match, they are returned face down. Then, you flip two other cards and so on until six minutes are over and the game closes automatically on you. In the process, you have to memorize the numbers or multiplications you have seen and where they are hidden. Once you solved an entire matrix of sixteen cards, another one automatically appears and you proceed with that one, until the game window closes. Further, it can happen that during the game, you will be interrupted by short messages that appear on the screen. If that happens, please ignore these interruptions. Now it's time for you to practice for a minute. Do you have any questions?

STROOP TASK

In this task you will be presented with color word names. Please name the color of the ink the words are printed in, ignoring the word that is printed in each item. In other words: Respond to the color of the words and ignore what the words say. Let me show you. For example, (point to the first item), this is the first item: what would you say? [If the subjects are correct, go on with the instructions. If incorrect, say]: "No, that is the word that is spelled there. Please say the color of the ink the word is printed in. Now (pointing to the same item) what would you say to this item? That's correct (point to second item), what would the response be to this item? [If correct, proceed; if incorrect, repeat the above as many times as necessary until the subjects understand the task or it becomes clear that it is impossible to go on.] It is important that you respond to all items as quickly as you can. Do you have any questions before we begin?

OPERATION SPAN TASK

In this task, you start a trial by clicking the “Next Trial” button. You will see a question involving a math problem. Please read the math problem thoroughly and then decide whether the given answer is correct or incorrect. If the answer is correct, click once on the “Yes” button; if the answer is incorrect, click once on the “No” button. You will then see a word. Read the word thoroughly. You will then see another math problem. At some point, you will be asked to recall all the words from the series. Simply click on the buttons that are labeled with words in the order in which you saw the words. However, answering the math problems correctly has top priority, and your recall of words is only relevant if the math problems were answered correctly. Once you are done, the experiment window will close automatically and a new window will appear. At that point, please do nothing and just raise your hand. Do you have any questions about this task?

APPENDIX D: INFORMED CONSENT LETTER

Consent Form for Participation in a Research Study
Clemson University

The Impact of Information Technology-Enabled Stressors in the Workplace

Description of the research and your participation

You are invited to participate in this study, designed to measure stress in the workplace. You will be recruited along with approximately 125 other people. Your participation and responses will contribute to a comprehensive understanding of employee needs and concerns regarding these processes and supportive activities.

The main goal of this experiment is to examine technological interruptions in IT environments, and provide solutions to this reoccurring problem. In doing so, we examine three broad constructs: demands, technology-enabled controls, and strain. You will be asked to perform a performance task on the computer. During your completion of the task, you will receive a series of interruptions. They will come electronically through instant messenger.

The experiment is designed to evaluate performance and stress responses regarding these tasks. To do this, this experiment uses non-invasive tools that capture various indicators of strain at frequent time periods. The tools to be used are salivettes, which are a standardized method for capturing salivary stress measures. The experiment follows up each episode with a quick survey.

The duration of the experiment should take approximately 2 hours and relates to how different technology characteristics can either influence or mitigate stress in the workplace.

Risks and discomforts

Because our techniques used to measure stress are non-invasive, you will be exposed to minimal risk. However, since the study is designed to examine stress effects, consequently you may feel discomfort from a temporary increase in stress levels. This discomfort is designed to be no more than you would receive in an everyday worklife environment. Results from this empirical study will contribute to a greater understanding of stress and technology in the workplace.

Incentives

Upon completion of this study, you will receive a reward of up to $15. The lottery for the Amazon Kindle, the Apple TV, and the Nintendo Wii will occur after the study will have been completed.

Protection of confidentiality

Your responses will remain confidential. Your name is for the sole purpose of ensuring you receive up to $15 incentive for your efforts and can be included in the lottery for the Amazon Kindle (a reader for eBooks), the Apple TV, and the Nintendo Wii. You will receive a number of lottery tickets reflective of your performance in the memory game Concentration you are about to play. For each matching pair of playing cards you uncover in this game, you will earn one lottery ticket. You will enter the lottery with all the lottery tickets you earned. Hence, the more lottery tickets you earn by uncovering matching pairs, the greater your chances of winning one or more of these 3 valuable prices. We will do everything we can to protect your privacy, and your identity will not be used as part of the data for this study and will not be revealed in any publication that might result from this study. Further, any link between your name and your performance will be destroyed as soon as the prices will have been awarded.

In rare cases, a research study will be evaluated by an oversight agency, such as the Clemson University Institutional Review Board or the federal Office for Human

Research Protections, that would require that we share the information we collect from you. If this happens, the information would only be used to determine if we conducted this study properly and adequately protected your rights as a participant.

Voluntary participation

Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. Refusal to participate or withdrawal from participation will not involve any penalty or loss of benefits to which you are otherwise entitled.

Early Termination

Persons who have known heart conditions or diagnosed elevated stress levels are not eligible to participate. Additionally, if it becomes apparent during your participation that you are in distress, the investigator can terminate the participation without your consent. The procedure for an orderly termination will involve the investigator stopping the experiment and asking you how you feel. If issues are confirmed, the investigator will inform you that your participation is finished and the reasonings behind early termination.

Early termination for reasons of known heart conditions or diagnosed elevated stress levels will not involve any penalty or loss of benefits to which you are otherwise entitled. However, if you did not comply with the requests specified in your invitation letter (e.g., no caffeine intake prior to participation), your participation can be ended early by the investigator and may involve the loss of benefits.

Contact information

The researcher, Mr. Stefan Tams, can be reached at stams@clemson.edu. His faculty supervisors, Dr. Jason Thatcher and Dr. Varun Grover, can be reached at jthatch@clemson.edu and vgrover@clemson.edu, respectively. In addition, Dr. Thatcher can be reached per phone at (864) 656-3751. You may contact the Institutional Review Board at (864) 656-6460 if you have any questions regarding your rights as a participant.

Consent

Signing this form will imply that you have read and understood the foregoing descriptions of this research project. You are entitled to ask for and receive a satisfactory explanation of any language that you don't fully understand.

I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.

Participant's name: ___________________________________

Participant's signature: ________________________________ Date: ______________

A copy of this consent form should be given to you.

References

Agarwal, R. and Prasad, J. (1998) A conceptual and operational definition of personal innovativeness in the domain of information technology, *Information Systems Research*, 9, 2.

Ahuja, M. K. and Thatcher, J. B. (2005) Moving beyond intentions and toward the theory of trying: Effects of work environment and gender on post-adoption information technology use, *MIS Quarterly,* 29, 3, 427-459.

Alfredsson, L., Karasek, R. and Theorell, T. (1982) Myocardial infarction risk and psychosocial work environment: An analysis of the male swedish working force, *Social Science & Medicine (1982),* 16, 4, 463-467.

Allard, E. S. and Isaacowitz, D. M. (2008) Are preferences in emotional processing affected by distraction? examining the age-related positivity effect in visual fixation within a dual-task paradigm, *Aging, Neuropsychology & Cognition,* 15, 6, 725-743.

Amabile, T. M. (1998) HOW TO KILL CREATIVITY, *Harvard Business Review* (76:5), 76-87.

Amabile, T. M. and Khaire, M. (2009) Creativity and the role of the leader, *Harvard Business Review* (87:3), 117-117.

Amirkhan, J. and Auyeung, B. (2007) Coping with stress across the lifespan: Absolute vs. relative changes in strategy, *Journal of Applied Developmental Psychology,* 28, 4, 298-317.

Andrés, P., Parmentier, F. B. R. and Escera, C. (2006) The effect of age on involuntary capture of attention by irrelevant sounds: A test of the frontal hypothesis of aging, *Neuropsychologia,* 44, 12, 2564-2568.

Arning, K. and Ziefle, M. (2009) Effects of age, cognitive, and personal factors on PDA menu navigation performance, *Behaviour & Information Technology,* 28, 3, 251-268.

Ayyagari, R., Grover, V. and Purvis, R. L. (forthcoming) Technostress: Technological antecedents and implications, *MIS Quarterly,*

Bacharach, S. B. (1989) Organizational theories: Some criteria for evaluation, *Academy of Management Review,* 14, 4, 496-515.

Bai, B.X., Smith, W., Cai, L.A., O'Leary, J.T. (1999). Senior-sensitive segments: Looking at travel behavior. In Chon K.S. (Ed.), *Graduate research in hospitality and tourism* (1.th ed., pp. 75-89). USA: NY: The Haworth Press.

Baker-Ward, L. and Ornstein, P. A. (1988) Age differences in visual-spatial memory performance: Do children really out-perform adults when playing concentration? *Bulletin of the Psychonomic Society,* 26, 4, 331-332.

Bandura, A. (1982) Self-efficacy mechanism in human agency, *American Psychologist,* 37, 2, 122-147.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ US: Prentice-Hall, Inc.

Bandura, A. (1989) Regulation of cognitive processes through perceived self-efficacy, *Developmental Psychology,* 25, 5, 729-735.

Bandura, A. (1994). Self-efficacy. In V. S. Ramachandran (Ed.), *Encyclopedia of human behavior* (pp. 71-81). New York: Academic Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York, NY US: W H Freeman/Times Books/ Henry Holt & Co.

Barney, J. (1991) Firm resources and sustained competitive advantage, *Journal of Management,* 17, 1, 99-120.

Baron, R. M. and Kenny, D. A. (1986) The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations, *Journal of Personality and Social Psychology,* 51, 6, 1173-1182.

Basoglu, A. and Fuller, M. (2007) Technology mediated interruptions: The effects of task and interruption characteristics on decision-making, *AMCIS 2007 Proceedings,* 240.

Baus, R. D. and Welch, S. -. (2008) Communication students' mathematics anxiety: Implications for research methods instruction, *Communication Research Reports,* 25, 4, 289-299.

Baynes, K., Sabeh, C. and Samuel, W. (1978) Effects of initial success or failure in a stressful or relaxed environment on subsequent task performance, *Journal of Experimental Social Psychology,* 14, 205-216.

Bayot, B., Sonnenholzner, S., Ochoa, X., Guerrerro, J., Vera, T., Calderón, J., et al. (2008) An online operational alert system for the early detection of shrimp epidemics at the regional level based on real-time production, *Aquaculture,* 277, 3, 164-173.

Beaudry, A. and Pinsonneault, A. (2005) Understanding user responses to information technology: A coping model of user adaptation, *MANAGEMENT INFORMATION SYSTEMS QUARTERLY,* 29, 3, 493-524.

Beckers, J. J. and Schmidt, H. G. (2003) Computer experience and computer anxiety, *Computers in Human Behavior,* 19, 6, 785.

Bell, R. and Buchner, A. (2007) Equivalent irrelevant-sound effects for old and young adults, *MEMORY AND COGNITION,* 35, 2, 352-364.

Benbasat, I. and Zmud, R. W. (1999) Empirical research in information systems: The practice of relevance, *MIS Quarterly,* 23, 1, 3-16.

Berti, S., Roeber, U. and Schröger, E. (2004) Bottom-up influences on working memory: Behavioral and electrophysiological distraction varies with distractor strength, *Experimental Psychology,* 51, 4, 249-257.

BIOCCA, F., OWEN, C., TANG, A. and BOHIL, C. (2007) Attention issues in spatial information systems: Directing mobile users' visual attention using augmented reality, *Journal of Management Information Systems,* 23, 4, 163-184.

Birdi, K. S. and Zapf, D. (1997) Age differences in reactions to errors in computer-based work, *Behaviour & Information Technology,* 16, 6, 309-319.

Blau, G. (1981) An empirical investigation of job stress, social support, service length, and job strain, *Organizational Behavior & Human Performance*, 27, 2, 279.

Boduroglu, A., Minear, M., & Shah, P. (2007). Working memory. In T. J. Perfect (Ed.), *Handbook of applied cognition (2nd ed.).* (pp. 55-82). Hoboken, NJ US: John Wiley & Sons Inc.

Bommer, W. H., Johnson, J., Rich, G. A. and Podsakoff, P. M. (1995) On the interchangeability of objective and subjective measures of employee performance: A meta-analysis, *Personnel Psychology* (48:3), 587-605.

Borsuk, G. M. and Coffey, T. (2003) Moore's law: A department of defense perspective, *Defense Horizons* 30, 1-8.

Bozionelos, N. (2004) Socio-economic background and computer use: The role of computer anxiety and computer experience in their relationship, *INTERNATIONAL JOURNAL OF HUMAN COMPUTER STUDIES,* 61, 5, 725-746.

Burton-Jones, A. (2009) Minimizing method bias through programmatic research, *MIS Quarterly,* 33, 3, 445-A7.

Burton-Jones, A. and Straub, D. W., Jr. (2006) Reconceptualizing system usage: An approach and empirical test, *Information Systems Research,* 17, 3, 228-246.

CAO, A., CHINTAMANI, K. K., PANDYA, A. K. and ELLIS, R. D. (2009) NASA TLX: Software for assessing subjective mental workload, *Behavior Research Methods*, 41, 1, 113-117.

Caplan, R. D. (1987) Person-environment fit theory and organizations: Commensurate dimensions, time perspectives, and mechanisms, *Journal of Vocational Behavior,* 31, 3, 248-67.

Caplan, R. D. and Van Harrison, R. (1993) Person-environment fit theory: Some history, recent developments, and future directions, *Journal of Social Issues,* 49, 4, 253-275.

Carlson, M. C., Hasher, L., Connelly, S. L. and Zacks, R. T. (1995) Aging, distraction, and the benefits of predictable location, *Psychology and Aging,* 10, 3, 427-436.

Carter, M., Thatcher, J. B., Applefield, C., and Mcalpine, J. (2011) What Cell Phones Mean in Young People's Daily Lives and Social Interactions, *SAIS 2011 Proceedings*.

Chang, C., Rosen, C. C. and Levy, P. E. (2009) The relationship between perceptions of organizational politics and employee attitudes, strain, and behavior: A meta-analytic examination, *Academy of Management Journal,* 52, 4, 779-801.

Charness, N., Holley, P., Feddon, J. and Jastrzembski, T. (2004) Light pen use and practice minimize age and hand performance different in pointing tasks, *Human Factors,* 46, 3, 373-384.

Chilton, M. A., Hardgrave, B. C. and Armstrong, D. J. (2005) Person-job cognitive style fit for software developers: The effect on strain and performance, *Journal of Management Information Systems,* 22, 2, 193-226.

Chin, W. W. (1998). *Issues and opinion on structural equation modeling* MIS Quarterly & The Society for Information Management.

Christ, S. E., Castel, A. D. and Abrams, R. A. (2008) Capture of attention by new motion in young and older adults, *Journals of Gerontology Series B: Psychological Sciences & Social Sciences,* 63B, 2, P110-P116.

Churchill, G. A. (1979) A paradigm for developing better measures of marketing constructs, *Journal of Marketing Research,* 16, 1, 64-73.

Cohen, J. (1977). *Statistical power analysis for the behavioral sciences (rev. ed.).* Hillsdale, NJ England: Lawrence Erlbaum Associates, Inc.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences (3rd ed.)*. Mahwah, NJ US: Lawrence Erlbaum Associates Publishers.

Colcombe, A. M., Kramer, A. F., Irwin, D. E., Peterson, M. S., Colcombe, S. and Hahn, S. (2003) Age-related effects of attentional and oculomotor capture by onsets and color singletons as a function of experience, *Acta Psychologica,* 113, 2, 205-225.

Cole, G. G., Kentridge, R. W., Gellatly, A. R. H. and Heywood, C. A. (2003) Detectability of onsets versus offsets in the change detection paradigm, *Journal of Vision,* 3, 1, 22-31.

Collerton, J., Collerton, D., Arai, Y., Barrass, K., Eccles, M., Jagger, C., et al. (2007) A comparison of computerized and pencil-and-paper tasks in assessing cognitive function in community-dwelling older people in the newcastle 85+ pilot study, *Journal of the American Geriatrics Society,* 55, 10, 1630-1635.

Compeau, D. R. and Higgins, C. A. (1995) Computer self-efficacy: Development of a measure and initial test, *MIS Quarterly,* 19, 2, 189-211.

Connelly, S. L. and Hasher, L. (1993) Aging and the inhibition of spatial location, *Journal of Experimental Psychology: Human Perception and Performance,* 19, 6, 1238-1250.

Connelly, S. L., Hasher, L. and Zacks, R. T. (1991) Age and reading: The impact of distraction, *Psychology and Aging,* 6, 4, 533-541.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design & analysis issues for field settings*. Chicago, IL: Rand McNally.

Cooper, C. L., Dewe, P. J., & O'Driscoll, M. P. (2001). *Organizational stress: A review and critique of theory, research, and applications*. Thousand Oaks, CA US: Sage Publications, Inc.

Cooper, R. B. and Zmud, R. W. (1990) Information technology implementation research: A technological diffusion approach, *Management Science*, 36, 2, 123-139.

Cowen, M. K., Wakefield, D. B. and Cloutier, M. M. (2007) Classifying asthma severity: Objective versus subjective measures, *Journal of Asthma* (44:9), 711-715.

Cui, K., Sun, L. and Yu, M. (2008) The difference of subjective mental workload between type A and type B men, *Chinese Mental Health Journal,* 22, 4, 298-301.

Czaja, S. J., Charness, N., Fisk, A. D., Hertzog, C., Nair, S. N., Rogers, W. A., et al. (2006) Factors predicting the use of technology: Findings from the center for research and education on aging and technology enhancement (create), *Psychology and Aging,* 21, 2, 333-352.

Czaja, S. J. and Sharit, J. (1993) Stress reactions to computer-interactive tasks as a function of task structure and individual differences, *International Journal of Human-Computer Interaction,* 5, 1, 1.

Czaja, S. J. and Sharit, J. (1998) Ability–performance relationships as a function of age and task experience for a data entry task, *Journal of Experimental Psychology: Applied,* 4, 4, 332-351.

Czaja, S. J., Sharit, J., Nair, S. and Rubert, M. (1998) Understanding sources of user variability in computer-based data entry performance, *Behaviour & Information Technology,* 17, 5, 282-293.

Dabbish, L. and Kraut, R. (2008) Awareness displays and social motivation for coordinating communication, *Information Systems Research,* 19, 2, 221-238.

Damrad-Frye, R. and Laird, J. D. (1989) The experience of boredom: The role of the self-perception of attention, *Journal of Personality and Social Psychology,* 57, 2, 315-320.

Dark-Freudeman, A., West, R. L. and Viverito, K. M. (2006) Future selves and aging: Older adults' memory fears, *Educational Gerontology,* 32, 2, 85-109.

Darowski, E. S., Helder, E., Zacks, R. T., Hasher, L. and Hambrick, D. Z. (2008) Age-related differences in cognition: The role of distraction control, *Neuropsychology,* 22, 5, 638-644.

Davenport, T. H. and Prusak, L. (2000) *Working knowledge: How organizations manage what they know*, Harvard Business School Press Books.

Davis, F. D., Bagozzi, R. P. and Warshaw, P. R. (1989) User acceptance of computer technology: A comparison of two theoretical models, *Management Science*, 35, 8, 982-1003.

Davis, F. D. and Yi, M. Y. (2004) Improving computer skill training: Behavior modeling, symbolic mental rehearsal, and the role of knowledge structures, *Journal of Applied Psychology,* 89, 3, 509-523.

Dennis, A. R. and Valacich, J. S. (2001) Conducting experimental research in information systems, *Communications of the Association for Information Systems,* 7, 5, 1-41.

Dennis, A. R. and Kinney, S. T. (1998) Testing media richness theory in the new media: The effects of cues, feedback, and task equivocality, *Information Systems Research,* 9, 3, 256-274.

Dickerson, S. S. and Kemeny, M. E. (2004) Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research, *Psychological Bulletin,* 130, 3, 355-391.

Dumas, J. A. and Hartman, M. (2008) Adult age differences in the access and deletion functions of inhibition, *Aging, Neuropsychology, and Cognition,* 15, 3, 330-357.

Edwards, J. R. (1996) An examination of competing versions of the person-environment fit approach to stress, *Academy of Management Journal*, 39, 2, 292-339.

Eggemeier, F. T. (1988). Properties of workload assessment techniques. In P. A. Hancock, & N. Meshkati (Eds.), *Human mental workload* (pp. 41-62). Amsterdam: Elsevier.

Endsley, M. R. (1995) Toward a theory of situation awareness in dynamic systems, *Human Factors*, 37, 1, 32-64.

Ericsson, K. A. and Kintsch, W. (1995) Long-term working memory, *Psychological Review,* 102, 2, 211-245.

Ericsson, K. A., Krampe, R. T. and Tesch-Römer, C. (1993) The role of deliberate practice in the acquisition of expert performance, *Psychological Review,* 100, 3, 363-406.

Escera, C. and Corral, M. J. (2007) Role of mismatch negativity and novelty-P3 in involuntary auditory attention, *Journal of Psychophysiology,* 21, 3, 251-264.

Eskritt, M., Lee, K. and Donald, M. (2001) The influence of symbolic literacy on memory: Testing plato's hypothesis, *Canadian Journal of Experimental Psychology/Revue Canadienne De Psychologie Expérimentale,* 55, 1, 39-50.

Fast, L. A., Lewis, J. L., Bryant, M. J., Bocian, K. A., Cardullo, R. A., Rettig, M., et al. (2010) Does math self-efficacy mediate the effect of the perceived classroom environment on standardized math test performance? *Journal of Educational Psychology,* 102, 3, 729-740.

Faul, F., Erdfelder, E., Buchner, A. and Lang, A. (2009) Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses, *Behavior Research Methods,* 41, 4, 1149-1160.

Fisher, D. L., Coury, B. G., Tengs, T. O. and Duffy, S. A. (1989) Minimizing the time to search visual displays: The role of highlighting, *Human Factors,* 31, 2, 167-182.

Folkman, S., & Lazarus, A. L. (1984). *Stress, appraisal and coping*. New York: Springer.

Fornell, C. and Larcker, D. F. (1981) Evaluating structural equation models with unobservable variables and measurement error, *Journal of Marketing Research (JMR),* 18, 1, 39-50.

Forth, J. and McNabb, R.(2008) Workplace performance: A comparison of subjective and objective measures in the 2004 workplace employment relations survey, *Industrial Relations Journal* (39:2), 104-123.

Franconeri, S. L. and Simons, D. J. (2003) Moving and looming stimuli capture attention, *Perception & Psychophysics,* 65, 7, 999-1010.

French, J. R. P., Caplan, R. D., and Van Harrison, R. (1982). *The mechanisms of job stress and strain*. Chichester, England: J. Wiley.

French, J. R. P., Rodgers, W., and Cobb, S. (1974). Adjustment as person-environment fit. In G. V. Coelho, D. A. Hamburg. & J. E. Adams (Ed.), (pp. 316-333). New York: Basic Books.

Gaillard, A. W. K. (2008). Concentration, stress and performance. In P. A. Hancock & J. L. Scalma (Ed.), (pp. 59-75) Ashgate Pub Co.

Galluch, P. S. (2009). *Interrupting the workplace: Examining stressors in an information technology context.* Unpublished Doctoral Dissertation, Clemson University, Clemson, SC.

Gellatly, A., Jones, S. and Best, A. (1988) The development of skill at concentration, *Australian Journal of Psychology,* 40, 1, 1-10.

Gillham, J., & Reivich, K. (2007). In Reevy G. (Ed.), *Cultivating optimism in childhood and adolescence*. Westport, CT US: Praeger Publishers/Greenwood Publishing Group.

Ginn, J. and Arber, S. (1996) Gender, age and attitudes to retirement in mid-life, *Ageing & Society,* 16, 1, 27.

Gonzalez, C. (2004) Learning to make decisions in dynamic environments: Effects of time constraints and cognitive abilities, *Human Factors: The Journal of the Human Factors and Ergonomics Society,* 46, 3, 449-460.

Granger, D. A., Kivlighan, K. T., El-Sheikh, M., Gordis, E. B., & Stroud, L. R. (2007). *Salivary alpha-amylase in biobehavioral research: Recent developments and applications*

Greengard, S. (2009) Facing an age-old problem, *Communications of the ACM,* 52, 9, 20-22.

Gumenyuk, V., Korzyukov, O., Alho, K., Escera, C., Schröger, E., Ilmoniemi, R. J., et al. (2001) Brain activity index of distractibility in normal school-age children, *Neuroscience Letters,* 314, 3, 147-150.

Gumenyuk, V., Korzyukov, O., Alho, K., Escera, C. and Näätänen, R. (2004) Effects of auditory distraction on electrophysiological brain activity and performance in children aged 8–13 years, *Psychophysiology,* 41, 1, 30-36.

Hadlington, L., Bridges, A. M. and Darby, R. J. (2004) Auditory location in the irrelevant sound effect: The effects of presenting auditory stimuli to either the left ear, right ear or both ears, *Brain & Cognition,* 55, 3, 545-557.

Hallfors, D., Khatapoush, S., Kadushin, C., Watson, K. and Saxe, L. (2000) A comparison of paper vs computer-assisted self interview for school alcohol, tobacco, and other drug surveys, *Evaluation and Program Planning,* 23, 2, 149-155.

Hansen, J. C., Neuman, J. L., Haverkamp, B. E. and Lubinski, B. R. (1997) Comparison of user reaction to two methods of strong interest inventory administration and report feedback, *Measurement and Evaluation in Counseling and Development,* 30, 3, 115-27.

Harrison, A. W. and Rainer Jr., R. K. (1992) The influence of individual differences on skill in end-user computing, *Journal of Management Information Systems,* 9, 1, 93-111.

Hart, P. M., & Cooper, C. L. (2002). Occupational stress: Toward a more integrated framework. In C. Viswesvaran (Ed.), *Handbook of industrial, work and organizational psychology, volume 2: Organizational psychology.* (pp. 93-114). Thousand Oaks, CA US: Sage Publications, Inc.

Hart, S. G., & Staveland, L. E. (1988). Development of NASA-TLX (task load index): Results of empirical and theoretical research. In N. Meshkati (Ed.), *Human mental workload.* (pp. 139-183). Oxford England: North-Holland.

Hasan, B. and Ali, J. M. H. (2004) An empirical examination of a model of computer learning performance, *Journal of Computer Information Systems,* 44, 4, 27-33.

Hasher, L., Stoltzfus, E. R., Zacks, R. T. and Rypma, B. (1991) Age and inhibition, *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 17, 1, 163-169.

Hasher, L., & Zacks, R. T. (1988). Working memory, comprehension, and aging: A review and a new view. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory, vol. 22.* (pp. 193-225). San Diego, CA US: Academic Press.

Hasher, L., Zacks, R. T., & May, C. P. (1999). Inhibitory control, circadian arousal, and age. In A. Koriat (Ed.), *Attention and performance XVII: Cognitive regulation of performance: Interaction of theory and application.* (pp. 653-675). Cambridge, MA US: The MIT Press.

Hawthorn, D. (2007) Interface design and engagement with older people, *Behaviour & Information Technology,* 26, 4, 333-341.

Hayes, A. (2009) Beyond baron and kenny: Statistical mediation analysis in the new millennium, *Communication Monographs,* 76, 4, 408-420.

Heinssen, R. K., Glass, C. R. and Knight, L. A. (1987) Assessing computer anxiety: Development and validation of the computer anxiety rating scale, *Computers in Human Behavior,* 3, 1, 49-59.

Hennington, A., Janz, B., Amis, J. and Nichols, E. (2009) Information systems and healthcare XXXII: Understanding the multidimensionality of information systems use: A study of nurses' use of a mandated electronic medical record system, *Communications of AIS* (2009:25), 243-262.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004) Design science in information systems research, *MIS Quarterly* (28:1), 75-105.

Horton, S. V. and Lovitt, T. C. (1994) A comparison of two methods of administering group reading inventories to diverse learners, *Remedial & Special Education*, 15, 6, 378.

Houghton, G., & Tipper, S. P. (1994). A model of inhibitory mechanisms in selective attention. In T. H. Carr (Ed.), *Inhibitory processes in attention, memory, and language.* (pp. 53-112). San Diego, CA US: Academic Press.

Huang, L. and Pashler, H. (2005) Quantifying object salience by equating distractor effects, *Vision Research,* 45, 14, 1909-1920.

Huber, G. P. (1983) Cognitive style as a basis for mis and dss designs: Much ado about nothing? *Management Science,* 29, 5, 567-579.

Igbaria, M., Iivari, J. and Maragahh, H. (1995) Why do individuals use computer technology? A finnish case study, *Information & Management,* 29, 227-238.

Jarvenpaa, S. L. and Majchrzak, A. (2008) Knowledge collaboration among professionals protecting national security: Role of transactive memories in ego-centered knowledge networks, *Organization Science,* 19, 2, 260-276.

Jasperson, J. (., Carter, P. E. and Zmud, R. W. (2005) A comprehensive conceptualization of post-adoptive behaviors associated with information technology enabled work systems, *MIS Quarterly,* 29, 3, 525-557.

Jeng, J. (2005) Usability assessment of academic digital libraries: Effectiveness, efficiency, satisfaction, and learability, *Libri: International Journal of Libraries & Information Services,* 55, 2, 96-121.

Jett, Q. R. and George, J. M. (2003) Work interrupted: A closer look at the role of interruptions in organizational life, *ACADEMY OF MANAGEMENT REVIEW,* 28, 494-509.

Jex, S. M. and Bliese, P. D. (1999) Efficacy beliefs as a moderator of the impact of work-related stressors: A multilevel study, *Journal of Applied Psychology,* 84, 3, 349-361.

Jex, S. M. and Gudanowski, D. M. (1992) Efficacy beliefs and work stress: An exploratory study, *Journal of Organizational Behavior,* 13, 5, 509-517.

Jiang, Z. and Benbasat, I. (2007) The effects of presentation formats and task complexity on online consumers' product understanding, *MIS Quarterly,* 31, 3, 475-500.

Jones, D. M. and Macken, W. J. (1993) Irrelevant tones produce an irrelevant speech effect: Implications for phonological coding in working memory, *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 19, 2, 369-381.

Jones, D. M., Saint-Aubin, J. and Tremblay, S. (1999) Modulation of the irrelevant sound effect by organizational factors: Further evidence from streaming by location, *Quarterly Journal of Experimental Psychology: Section A*, 52, 3, 545-554.

Jurado, M. and Rosselli, M. (2007) The elusive nature of executive functions: A review of our current understanding, *Neuropsychology Review*, 17, 3, 213-233.

Kahai, S. S. and Cooper, R. B. (1999) The effect of computer-mediated communication on agreement and acceptance, *Journal of Management Information Systems*, 16, 1, 165-188.

Kahn, R. L., & Byosiere, P. (1992). Stress in organizations. In L. M. Hough (Ed.), *Handbook of industrial and organizational psychology, vol. 3 (2nd ed.).* (pp. 571-650). Palo Alto, CA US: Consulting Psychologists Press.

Kaldenberg, D. O. and Becker, B. W. (1992) Workload and psychological strain: A test of the french, rodgers, and cobb hypothesis, *Journal of Organizational Behavior*, 13, 6, 617-624.

Kane, M. J., Hasher, L., Stoltzfus, E. R., Zacks, R. T. and Connelly, S. L. (1994) Inhibitory attentional mechanisms and aging, *Psychology and Aging*, 9, 1, 103-112.

Kar, Y. T. and Shuk, Y. H. (2006) Understanding the impact of web personalization on user information processing and decision outcomes, *MIS Quarterly*, 30, 4, 865-890.

Karasek, R. A. (1979) Job demands, job decision latitude, and mental strain: Implications for job redesign, *Administrative Science Quarterly*, 24, 2, 285-308.

Karasek, R., Baker, D., Marxer, F., Ahlbom, A. and Theorell, T. (1981) Job decision latitude, job demands, and cardiovascular disease: A prospective study of swedish men, *American Journal of Public Health*, 71, 7, 694-705.

Kasl, S. (1989). An epidemiological perspective on the role of control in health. In S. L. Sauter, J. J. Hurrell, & C. L. Cooper (Ed.), (pp. 161-189). Chichester, England: Wiley.

Katona, G. (1976) On subjective and objective measures, *American Psychologist* (31:8), 617-617.

Kausler, D. H. (1994). *Learning and memory in normal aging*. San Diego, CA US: Academic Press.

Keen, P. G. W. (1980). MIS research: Reference disciplines and a cumulative tradition. Philadelphia, PA. 9-18.

Kenny, D. A., Kashy, D. A., & Bolger, N. (1998). Data analysis in social psychology. In D. T. Gilbert, S. T. Fiske, G. Lindzey, D. T. Gilbert, S. T. Fiske & G. Lindzey (Eds.), *The handbook of social psychology, vols. 1 and 2 (4th ed.).* (pp. 233-265). New York, NY US: McGraw-Hill.

Kil-Soo Suh and Young, E. L. (2005) The effects of virtual reality on consumer learning: An empirical investigation, *MIS Quarterly,* 29, 4, 673-697.

Kim, S., Hasher, L. and Zacks, R. T. (2007) Aging and benefit of distractibility, *Psychonomic Bulletin & Review,* 14, 2, 301-305.

Kirby, J. (2010) Brains to spare, *Harvard Business Review* (88:7), 166-166.

Klein, L. C., Bennett, J. M., Whetzel, C. A., Granger, D. A. and Ritter, F. E. (2010) Caffeine and stress alter salivary α-amylase activity in young men, *Human Psychopharmacology: Clinical & Experimental*, 25, 5, 359-367.

Koelewijn, T., Bronkhorst, A. and Theeuwes, J. (2009) Auditory and visual capture during focused visual attention, *Journal of Experimental Psychology: Human Perception and Performance,* 35, 5, 1303-1315.

Kopcso, D., Pipino, L. and Rybolt, W. (1988) A comparison of the manipulation of certainty factors by individuals and expert system shells, *Journal of Management Information Systems,* 5, 1, 66-81.

Kramer, A. F., Hahn, S., Irwin, D. E. and Theeuwes, J. (1999) Attentional capture and aging: Implications for visual search performance and oculomotor control, *Psychology and Aging,* 14, 1, 135-154.

Kuhn, T.S. (1970) *The Structure of Scientific Revolutions,* 2d ed. Chicago: University of Chicago Press.

Laguna, K.,D. and Babcock, R.,L. (2000) Computer testing of memory across the adult life span, *Experimental Aging Research,* 26, 3, 229-243.

Lam, J. C. Y. and Lee, M. K. O. (2006) Digital inclusiveness--longitudinal study of internet adoption by older adults, *Journal of Management Information Systems,* 22, 4, 177-206.

Lang, J., Thomas, J. L., Bliese, P. D. and Adler, A. B. (2007) Job demands and job performance: The mediating effect of psychological and physical strain and the moderating effect of role clarity, *Journal of Occupational Health Psychology,* 12, 2, 116-124.

Lazarus, R. S. (1993) From psychological stress to the emotions: A history of changing outlooks, *Annual Review of Psychology,* 44, 1-21.

Lazarus, R. S. (1966). *Psychological stress and the coping process*. New York, NY US: McGraw-Hill.

Lazarus, R. S. (1998). Coping with aging: Individuality as a key to understanding. In P. Fromholt (Ed.), *Clinical geropsychology.* (pp. 109-127). Washington, DC US: American Psychological Association.

Lazarus, R. S. (1999). *Stress and emotion: A new synthesis*. New York, NY US: Springer Publishing Co.

Lee, Y., Lu, M. and Ko, H. (2007) Effects of skill training on working memory capacity, *Learning & Instruction,* 17, 3, 336-344.

Lim, K. H. and Benbasat, I. (2002) The influence of multimedia on improving the comprehension of organizational information, *Journal of Management Information Systems,* 19, 1, 99-127.

Liu, M., Schallert, D. L. and Carroll, P. J. (2004) Working memory and expertise in simultaneous interpreting, *Interpreting: International Journal of Research & Practice in Interpreting,* 6, 1, 19-42.

Lopata, C., Volker, M. A., Putnam, S. K., Thomeer, M. L. and Nida, R. E. (2008) Effect of social familiarity on salivary cortisol and self-reports of social anxiety and stress in children with high functioning autism spectrum disorders, *Journal of Autism & Developmental Disorders,* 38, 10, 1866-1877.

Lord, R. G., & Kanfer, R. (2002). Emotions and organizational behavior. In R. G. Lord, R. Klimoski & R. Kanfer (Eds.), *Emotions in the workplace: Understanding the structure and role of emotions in organizations* (pp. 5-19). San Francisco: Jossey-Bass.

Lorenzo-López, L., Amenedo, E. and Cadaveira, F. (2008) Feature processing during visual search in normal aging: Electrophysiological evidence, *Neurobiology of Aging*, 29, 7, 1101-1110.

Luoma, J., Flannagan, M. J., Sivak, M., Aoki, M. and Traube, E. C. (1997) Effects of turn-signal colour on reaction times to brake signals, *Ergonomics,* 40, 1, 62-68.

Luria, A. R. (1973). *The working brain: An introduction to neuropsychology*. New York: Basic.

MacKinnon, D. P., Lockwood, C. M., Hoffman, J. M., West, S. G. and Sheets, V. (2002) A comparison of methods to test mediation and other intervening variable effects, *Psychological Methods*, 7, 1, 83-104.

MacKinnon, D. P., Lockwood, C. M. and Williams, J. (2004) Confidence limits for the indirect effect: Distribution of the product and resampling methods, *Multivariate Behavioral Research,* 39, 1, 99-128.

MacKinnon, D. P. and Luecken, L. J. (2008) How and for whom? mediation and moderation in health psychology, *Health Psychology,* 27, 2, S99-S100.

Malhotra, N. K., Kim, S. S. and Patil, A. (2006) Common method variance in IS research: A comparison of alternative approaches and a reanalysis of past research, *Management Science*, 52, 12, 1865-1883.

Mandel, M., Hamm, S., Matlack, C., Farrell, C. and Palmer, A. T. (2005) The real reasons you're working so hard…. (cover story), *BusinessWeek*, 3953, 60-67.

Marakas, G. M., Johnson, R. D. and Clay, P. F. (2007) The evolving nature of the computer self-efficacy construct: An empirical investigation of measurement construction, validity, reliability and stability over time, *Journal of the Association for Information Systems*, 8, 1, 15-46.

Marakas, G. M., Yi, M. Y. and Johnson, R. D. (1998) The multilevel and multifaceted character of computer self-efficacy: Toward clarification of the construct and an integrative framework for research, *Information Systems Research,* 9, 2, 126-163.

Martin, M. K., Gonzalez, C., & Lebiere, C. (2004). Learning to make decisions in dynamic environments: ACT-R plays the beer game. In M. Lovett, et al. (Eds.), *Proceedings of the sixth international conference on cognitive modeling: ICCCM 2004: Integrating models.* (pp. 178-183). Mahwah, NJ US: Lawrence Erlbaum Associates Publishers.

Mata, F. J., Fuerst, W. L. and Barney, J. B. (1995) Information technology and sustained competitive advantage: A resource-based analysis, *MIS Quarterly,* 19, 4, 487-505.

May, C. P., Zacks, R. T., Hasher, L. and Multhaup, K. S. (1999) Inhibition in the processing of garden-path sentences, *Psychology and Aging*, 14, 2, 304-313.

McDowd, J. M., & Shaw, R. J. (2000). Attention and aging: A functional perspective. In T. A. Salthouse (Ed.), *The handbook of aging and cognition (2nd ed.).* (pp. 221-292). Mahwah, NJ US: Lawrence Erlbaum Associates Publishers.

McGrath, J. E. (1976). Stress and behavior in organizations. In M. Dunnette (Ed.), (pp. 1351–1395). Chicago: Rand McNally.

McLeod, D. R., Griffiths, R. R., Bigelow, G. E. and Yingling, J. (1982) An automated version of the digit symbol substitution test (DSST), *Behavior Research Methods & Instrumentation,* 14, 5, 463-466.

McLeod, P., Driver, J., Dienes, Z. and Crisp, J. (1991) Filtering by movement in visual search, *Journal of Experimental Psychology: Human Perception and Performance,* 17, 1, 55-64.

Mead, A. D. and Drasgow, F. (1993) Equivalence of computerized and paper-and-pencil cognitive ability tests: A meta-analysis, *Psychological Bulletin,* 114, 3, 449-458.

Mead, S. E., Sit, R. A., Rogers, W. A., Jamieson, B. A. and Rousseau, G. K. (2000) Influences of general computer experience and age on library database search performance, *Behaviour & Information Technology,* 19, 2, 107-123.

Meyer, D. E. and Kieras, D. E. (1997) A computational theory of executive cognitive processes and multiple-task performance: I. basic mechanisms, *Psychological Review,* 104, 1, 3-65.

Milgrom, P. and Roberts, J. (1995) Complementarities and fit: Strategy, structure, and organizational change in manufacturing, *Journal of Accounting and Economics* (19:2-3), 179-208.

Miller, G. A. (1956) The magical number seven, plus or minus two: Some limits on our capacity for processing information, *Psychological Review,* 63, 2, 81-97.

Monat, A., Lazarus, R. S., and Reevy, G. (2007) In Reevy G. (Ed.), *The praeger handbook on stress and coping (vol.1).* Westport, CT US: Praeger Publishers/Greenwood Publishing Group.

Mook, D. G. (1983) In defense of external invalidity, *American Psychologist* (38:4), pp. 379-387.

Moore, J. E. (2000) One road to turnover: An examination of work exhaustion in technology professionals, *MIS Quarterly*, 24, 1, 141-168.

Morris, M. G. and Venkatesh, V. (2000) Age differences in technology adoption decisions: Implications for a changing work force, *Personnel Psychology,* 53, 2, 375-403.

Morris, M. G., Venkatesh, V. and Ackerman, P. L. (2005) Gender and age differences in employee decisions about new technology: An extension to the theory: Of planned behavior, *IEEE Transactions on Engineering Management*, 52, 1, 69-84.

Morrow, D. G., Menard, W. E., Ridolfo, H. E., Stine-Morrow, E., Teller, T. and Bryant, D. (2003) Expertise, cognitive ability, and age effects on pilot communication, *International Journal of Aviation Psychology,* 13, 4, 345.

Mossholder, K. W., Bedeian, A. G. and Armenakis, A. A. (1982) Group process-work outcome relationships: A note on the moderating impact of self-esteem, *Academy of Management Journal,* 25, 3, 575-585.

Mossholder, K., Bennett, N., Kemery, E. and Wesolowski, M. (1998) Relationships between bases of power and work reactions: The mediational role of procedural justice, *Journal of Management,* 24, 4, 533-552.

Murata, A. (2006) Eye-gaze input versus mouse: Cursor control as a function of age, *International Journal of Human-Computer Interaction,* 21, 1, 1-14.

Murata, A. and Iwase, H. (2005) Usability of touch-panel interfaces for older adults, *Human Factors,* 47, 4, 767-776.

Murphy, K. R. (1989) Is the relationship between cognitive ability and job performance stable over time? *Human Performance,* 2, 3, 183.

National Science Foundation. (2010) Higher education in science and engineering, *Science and Engineering Indicators: 2010,* 1-41.

Nauta, M. M., Liu, C. and Li, C. (2010) A cross-national examination of self-efficacy as a moderator of Autonomy/Job strain relationships, *Applied Psychology: An International Review,* 59, 1, 159-179.

NC3RS (National Centre for the Replacement, Refinement and Reduction of Animals in Research). (2006). *Why do a pilot study?*

Neumann, O. (1987). Beyond capacity: A functional view of attention. In A. F. Sanders (Ed.), *Perspectives on perception and action.* (pp. 361-394). Hillsdale, NJ England: Lawrence Erlbaum Associates, Inc.

Neupert, S. D., Miller, L. M. S., & Lachman, M. E. *Physiological reactivity to cognitive stressors: Variations by age and socioeconomic status* Baywood Publishing Company, Inc.

Newell, A. F., Dickinson, A., Smith, M. J. and Gregor, P. (2006) Designing a portal for older users: A case study of an Industrial/Academic collaboration, *ACM Transactions on Computer-Human Interaction (TOCHI),* 13, 3, 347-375.

Newson, R. S. and Kemps, E. B. (2006) The influence of physical and cognitive activities on simple and complex cognitive tasks in older adults, *Experimental Aging Research,* 32, 3, 341-362.

Nicholls, A., Polman, R., Morley, D. and Taylor, N. J. (2009) Coping and coping effectiveness in relation to a competitive sport event: Pubertal status, chronological age, and gender among adolescent athletes, *Journal of Sport & Exercise Psychology,* 31, 3, 299-317.

Norris, R., Carroll, D. and Cochrane, R. (1992) The effects of physical activity and exercise training on psychological stress and well-being in an adolescent population, *Journal of Psychosomatic Research,* 36, 55-65.

Noyes, J. M. and Bruneau, D. (2007) A self-analysis of the NASA-TLX workload measure, *Ergonomics,* 50, 4, 514-519.

Noyes, J. M. and Garland, K. J. (2008) Computer- vs. paper-based tasks: Are they equivalent? *Ergonomics,* 51, 9, 1352-1375.

Nunnally, J. C. (1978). *Psychometric theory*. New York, NY US: McGraw-Hill.

Orvis, K. A., Horn, D. B. and Belanich, J. (2009) An examination of the role individual differences play in videogame-based training, *Military Psychology,* 21, 4, 461-481.

Osipow, S. H., Doty, R. E. and Spokane, A. R. (1985) Occupational stress, strain, and coping across the life span, *Journal of Vocational Behavior,* 27, 1, 98-108.

Ozer, E. M. and Bandura, A. (1990) Mechanisms governing empowerment effects: A self-efficacy analysis, *Journal of Personality and Social Psychology,* 58, 3, 472-486.

Pacholski, L. (2006) Ergonomic issues of the neural integrated human-computer interaction, *Cybernetics & Systems* (37:2), pp. 219-228.

Pak, R., Price, M. M. and Thatcher, J. (2009) Age-sensitive design of online health information: Comparative usability study, *Journal of Medical Internet Research,* 11, 4, 6-6.

Panek, P. E. (1997). The older worker. In W. A. Rogers (Ed.), *Handbook of human factors and the older adult.* (pp. 363-394). San Diego, CA US: Academic Press.

Park, D. C. (2000). The basic mechanisms accounting for age-related decline in cognitive function. In N. Schwarz (Ed.), *Cognitive aging: A primer.* (pp. 3-21). New York, NY US: Psychology Press.

Parkes, K. R. (1989). Personal control in an occupational context. In A. Steptoe, & A. Appels (Ed.), (pp. 21-48). Chichester, England: Wiley.

Pervin, L. A. (1968) Performance and satisfaction as a function of individual-environment fit, *Psychological Bulletin*, 69, 1, 56-68.

Pinsoneault, T. B. (1996) Equivalency of computer-assisted and paper-and-pencil administered versions of the minnesota multiphasic personality inventory-2, *Computers in Human Behavior*, 12, 2, 291-300.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. and Podsakoff, N. P. (2003) Common method biases in behavioral research: A critical review of the literature and recommended remedies, *Journal of Applied Psychology*, 88, 5, 879-903.

Podsakoff, P. M. and Organ, D. W. (1986) Self-reports in organizational research: Problems and prospects, *Journal of Management*, 12, 4, 531.

Potosky, D. (2002) A field study of computer efficacy beliefs as an outcome of training: The role of computer playfulness, computer knowledge, and performance during training, *Computers in Human Behavior*, 18, 3, 241-256.

Potosky, D. and Bobko, P. (1998) The computer understanding and experience scale: A self-report measure of computer experience, *Computers in Human Behavior*, 14, 2, 337-348.

Potosky, D. and Bobko, P. (2001) A model for predicting computer experience from attitudes toward computers, *Journal of Business & Psychology*, 15, 3, 391-404.

Pratt, J. and Bellomo, C. N. (1999) Attentional capture in younger and older adults, *Aging, Neuropsychology & Cognition*, 6, 1, 19-31.

Preacher, K. J. and Hayes, A. F. (2004) SPSS and SAS procedures for estimating indirect effects in simple mediation models, *Behavior Research Methods, Instruments, & Computers*, 36, 4, 717-731.

Preacher, K. J. and Hayes, A. F. (2008) Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models, *Behavior Research Methods,* 40, 3, 879-891.

Radvansky, G. A., Gerard, L. D., Zacks, R. T. and Hasher, L. (1990) Younger and older adults' use of mental models as representations for text materials, *Psychology and Aging,* 5, 2, 209-214.

Radvansky, G. A., Zacks, R. T. and Hasher, L. (1996) Fact retrieval in younger and older adults: The role of mental models, *Psychology and Aging,* 11, 2, 258-271.

Ragu-Nathan, T., Tarafdar, M., Ragu-Nathan, B. and Tu, Q. (2008) The consequences of technostress for end users in organizations: Conceptual development and empirical validation, *Information Systems Research,* 19, 4, 417-433.

Reed, K., Doty, D. H. and May, D. R. (2005) The impact of aging on self-efficacy and computer skill acquisition, *Journal of Managerial Issues,* 17, 2, 212-228.

Remington, R. W., Johnston, J. C., Ruthruff, E., Gold, M. and Romera, M. (2000) Visual search in complex displays: Factors affecting conflict detection by air traffic controllers, *HUMAN FACTORS -NEW YORK THEN SANTA MONICA-,* 42, 349-366.

Ren, Y., Kiesler, S. and Fussell, S. R. (2008) Multiple group coordination in complex and dynamic task environments: Interruptions, coping mechanisms, and technology recommendations, *Journal of Management Information Systems,* 25, 1, 105-130.

Rich, G. A., Bommer, W. H., MacKenzie, S. B., Podsakoff, P. M. and Johnson, J. L. (1999) Apples and apples or apples and oranges? A meta-analysis of objective and subjective measures of salesperson performance, Journal *of Personal Selling & Sales Management* (19:4), 41-52.

Riemer, K. and Frößler, F. (2007) Introducing real-time collaboration systems: Development of a conceptual scheme and research directions, *Communications of AIS,* 2007, 20, 204-225.

Rivera, C., Ireland, T., & Reilly, D. (2006). *Terror alert levels and crime: An examination from a routine activities perspective*

Roberts, T. L., Cheney, P. H., Sweeney, P. D. and Hightower, R. T. (2004) The effects of information technology project complexity on group interaction, *Journal of Management Information Systems,* 21, 3, 223-247.

Rogers, W. A., Cabrera, E. F., Walker, N. and Gilbert, D. K. (1996) A survey of automatic teller machine usage across the adult life span, *Human Factors,* 38, 1, 156-166.

Rogers, W. A., & Fisk, A. D. (2001). Understanding the role of attention in cognitive aging research. In K. W. Schaie (Ed.), *Handbook of the psychology of aging (5th ed.).* (pp. 267-287). San Diego, CA US: Academic Press.

Rohleder, N., Wolf, J. M., Maldonado, E. F. and Kirschbaum, C. (2006) The psychosocial stress-induced increase in salivary alpha-amylase is independent of saliva flow rate, *Psychophysiology,* 43, 6, 645-652.

Rousseau, G. K., Jamieson, B. A., Rogers, W. A., Mead, S. E. and Sit, R. A. (1998) Assessing the usability of on-line library systems, *Behaviour & Information Technology,* 17, 5, 274-281.

Rubio, S., Díaz, E., Martín, J. and Puente, J. M. (2004) Evaluation of subjective mental workload: A comparison of SWAT, NASA-TLX, and workload profile methods, *Applied Psychology: An International Review,* 53, 1, 61-86.

Saeed, K. A., Abdinnour, S., Lengnick-Hall, M. L. and Lengnick-Hall, C. A. (2010) Examining the impact of Pre-Implementation expectations on Post-Implementation use of enterprise systems: A longitudinal study, *Decision Sciences* (41:4), 659-688.

Sagarin, B. J., Britt, M. A., Heider, J. D., Wood, S. E. and Lynch, J. E. (2003) Bartering our attention: The distraction and persuasion effects of on-line advertisements, *International Journal of Cognitive Technology,* 8, 2, 4-17.

Salimetrics, L. (2009). *Saliva collection and handling advice*

Salthouse, T. A. and Babcock, R. L. (1991) Decomposing adult age differences in working memory, *Developmental Psychology,* 27, 5, 763-776.

Salvato, C. (2009) Capabilities unveiled: The role of ordinary activities in the evolution of product development processes, *Organization Science,* 20, 2, 384-409.

Salvato, C. and Rerup, C. (2011) Beyond collective entities: Multilevel research on organizational routines and capabilities, *Journal of Management,* 37, 2, 468-490.

Schaufeli, W. B., Leiter. M. P., & Kalimo. R. (1995). The general burnout inventory: A self-report questionnaire to assess burnout at the workplace. *Work. Stress and Health '95: Creating Healthier Workplaces,* Schneider, W., Dumais, S. T., & Shiffrin, R. M. (1984). Automatic and control processing and attention. In R. Parasuraman & D. Davies (Ed.), *Varieties of attention* (pp. 1-27). New York: Academic Press.

Schultheiss, O. C., & Stanton, S. J. (2009). Assessment of salivary hormones. In E. Harmon-Jones, J. S. Beer, E. Harmon-Jones & J. S. Beer (Eds.), *Methods in social neuroscience.* (pp. 17-44). New York, NY US: Guilford Press.

Schumann-Hengsteler, R. (1996) Children's and adults' visuospatial memory: The game concentration, *Journal of Genetic Psychology*, 157, 1, 77.

Schutte, M. and Jordan, C. (1996) Dependence between performance, strain and strategies for an activity involving informational load, *Ergonomics*, 39, 7, 903.

Shadish, W. R., Cook, T. D., and Campbell, D. T. (2002) *Experimental and quasi-experimental designs for generalized causal inference*, Boston, MA US: Houghton, Mifflin and Company.

Sharit, J. and Czaja, S. J. (1994) Ageing, computer-based task performance, and stress: Issues and challenges, *Ergonomics*, 37, 4, 559-577.

Sharit, J., Czaja, S. J., Nair, S. N., Hoag, D. W., Leonard, D. C. and Dilsen, E. K. (1998) Subjective experiences of stress, workload, and bodily discomfort as a function of age and type of computer work, *Work & Stress,* 12, 2, 125-144.

Sharit, J. and Czaja, S. J. (1999) Performance of a computer-based troubleshooting task in the banking industry: Examining the effects of age, task experience, and cognitive abilities, *International Journal of Cognitive Ergonomics*, 3, 1, 1-22.

Shiffrin, R. M. and Schneider, W. (1977) Controlled and automatic human information processing: II. perceptual learning, automatic attending and a general theory, *Psychological Review*, 84, 2, 127-190.

Shilling, V. M., Chetwynd, A. and Rabbitt, P. M. A. (2002) Individual inconsistency across measures of inhibition: An investigation of the construct validity of inhibition in older adults, *Neuropsychologia*, 40, 6, 605.

Siegrist, J. (1996) Adverse health effects of high-effort/low-reward conditions, *Journal of Occupational Health Psychology*, 1, 1, 27-41.

Silver, M. S., Markus, M. L. and Beath, C. M. (1995) The information technology interaction model: A foundation for the MBA core course, *MIS Quarterly*, 19, 3, 361-390.

Simons, D. J. and Chabris, C. F. (1999) Gorillas in our midst: Sustained inattentional blindness for dynamic events, *Perception*, 28, 9, 1059-1074.

Smith, A. D. (1996). Memory. In T. A. Salthouse (Ed.), *Handbook of the psychology of aging (4th ed.).* (pp. 236-250). San Diego, CA US: Academic Press.

Smith, B., Caputi, P., Crittenden, N., Jayasuriya, R. and Rawstorne, P. (1999) A review of the construct of computer experience, *Computers in Human Behavior,* 15, 2, 227-242.

Smith, B., Caputi, P. and Rawstorne, P. (2000) Differentiating computer experience and attitudes toward computers: An empirical investigation, *Computers in Human Behavior,* 16, 1, 59-81.

Smith, B., Caputi, P. and Rawstorne, P. (2007) The development of a measure of subjective computer experience, *Computers in Human Behavior,* 23, 1, 127-145.

Smith, M. W. and Sharit, J. (1999) Aging, motor control, and the performance of computer mouse tasks, *Human Factors,* 41, 3, 389.

Sobel, M. E. (1982) Asymptotic confidence intervals for indirect effects in structural equation models, *Sociological Methodology,* 290.

Stephens, K. (2007) If you think we are overloaded now...: A cost-minimization perspective on managing workplace instant messaging use, *Conference Papers -- National Communication Association,* 1.

Sterns, H. L., Barrett, G. V., Czaja, S. J. and Barr, J. K. (1994) Issues in work and aging, *Journal of Applied Gerontology,* 13, 1, 7-19.

Stoltzfus, E. R., Hasher, L., Zacks, R. T. and Ulivi, M. S. (1993) Investigations of inhibition and interference in younger and older adults, *Journals of Gerontology,* 48, 4, P179-P188.

Straub, D. W. (1989) Validating instruments in MIS research, *MIS Quarterly,* 13, 2, 147-169.

Straub, D., Boudreau, M. and Gefen, D. (2004) Validation guidelines for is positivist research, *Communications of AIS,* 2004, 13, 380-427.

Strayer, D. L., & Drews, F. A. (2007). Attention. In T. J. Perfect (Ed.), *Handbook of applied cognition (2nd ed.).* (pp. 29-54). Hoboken, NJ US: John Wiley & Sons Inc.

Stroop, J. R. (1935) Studies of interference in serial verbal reactions, *Journal of Experimental Psychology,* 18, 6, 643-662.

Sturm, W., Longoni, F., Weis, S., Specht, K., Herzog, H., Vohn, R., et al. (2004) Functional reorganisation in patients with right hemisphere stroke after training of alertness: A longitudinal PET and fMRI study in eight cases, *Neuropsychologia,* 42, 4, 434.

Suls, J., & Mullen, B. (1982). From the cradle to the grave: Comparison and self-evaluation across the life-span. In J. Suls (Ed.), (pp. 97-125). Hillsdale, NJ: Lawrence Erlbaum Assoc Inc.

Sweller, J. (1988) Cognitive load during problem solving: Effects on learning, *Cognitive Science: A Multidisciplinary Journal,* 12, 2, 257-285.

Sweller, J. (1994) Cognitive load theory, learning difficulty. and instructional design, *Learning & Instruction,* 4, 4, 295-312.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics (5th ed.).* Boston, MA: Allyn & Bacon/Pearson Education.

TARAFDAR, M., QIANG, T. U., RAGU-NATHAN, B. and RAGU-NATHAN, T. (2007) The impact of technostress on role stress and productivity, *Journal of Management Information Systems,* 24, 1, 301-328.

Tarafdar, M., Tu, Q. and Ragu-Nathan, T. (2010) Impact of technostress on end-user satisfaction and performance, *Journal of Management Information Systems,* 27, 3, 303-334.

Taylor, S. and Todd, P. A. (1995) Understanding information technology usage: A test of competing models, *Information Systems Research,* 6, 2, 144-176.

Thatcher, J. B. and Perrewe, P. L. (2002) An empirical examination of individual traits as antecedents to computer anxiety and computer self-efficacy, *MANAGEMENT INFORMATION SYSTEMS QUARTERLY,* 26, 381-396.

Thatcher, J. B., Zimmer, J. C., Gundlach, M. J. and McKnight, D. H. (2008) Internal and external dimensions of computer self-efficacy: An empirical examination, *IEEE Transactions on Engineering Management,* 55, 4, 628-644.

Theeuwes, J. (1991) Cross-dimensional perceptual selectivity, *Perception & Psychophysics,* 50, 2, 184-193.

Theeuwes, J. (1994) Stimulus-driven capture and attentional set: Selective search for color and visual abrupt onsets, *Journal of Experimental Psychology: Human Perception and Performance,* 20, 4, 799-806.

Thompson, R. L., Higgins, C. A. and Howell, J. M. (1994) Influence of experience on personal computer utilization: Testing a conceptual model, *Journal of Management Information Systems,* 11, 1, 167-187.

Tomporowski, P. D. (2003) Performance and perceptions of workload among young and older adults: Effects of practice during cognitively demanding tasks, *Educational Gerontology,* 29, 5, 447.

Tripsas, M. (2009) Technology, identity, and inertia through the lens of "the digital photography company", *Organization Science* (20:2), 441-460.

Tu, Q., Wang, K. and Shu, Q. (2005) Computer-related technostress in china, *Communications of the ACM,* 48, 4, 77-81.

U.S. Bureau of Labor Statistics. (2008) BLS spotlight on statistics: Older workers, *U.S. Department of Labor*, 1-10.

U.S. Bureau of Labor Statistics. (2010) Career guide to industries: Computer systems design and related services (2010-11 edition), *U.S. Department of Labor,*

Uchino, B. N., Berg, C. A., Smith, T. W., Pearce, G. and Skinner, M. (2006) Age-related differences in ambulatory blood pressure during daily stress: Evidence for greater blood pressure reactivity with age, *Psychology and Aging,* 21, 2, 231-239.

Unger, J., Johnson, C. and Marks, G. (1997) Functional decline in the elderly: Evidence for direct and stress-buffering protective effects of social interactions and physical activity, *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine,* 19, 2, 152-160.

Van Fleet, C. and Antell, K. E. (2002) Creating CyberSeniors: Older adult learning and its implications for computer training, *Public Libraries,* 41, 3, 149-55.

Van Gerven, Pascal W. M., Paas, F. G. W. C., Van Merriënboer, Jeroen J. G. and Schmidt, H. G. (2000) Cognitive load theory and the acquisition of complex cognitive skills in the elderly: Towards an integrative framework, *Educational Gerontology,* 26, 6, 503-521.

Van Harrison, R. (1985). The person-environment fit model and the study of job stress. In T. A. Beehr & R. S. Bhagat (Ed.), (pp. 23-55). New York: John Wiley & Sons.

Venkatesh, V., Morris, M. G., Davis, G. B. and Davis, F. D. (2003) User acceptance of information technology: Toward a unified view, *MIS Quarterly,* 27, 3, 425-478.

Vispoel, W. P., Boo, J. and Bleiler, T. (2001) Computerized and paper-and-pencil versions of the rosenberg self-esteem scale: A comparison of psychometric features and respondent preferences, *Educational and Psychological Measurement,* 61, 3, 461-474.

Vispoel, W. P. (2000) Computerized versus paper-and-pencil assessment of self-concept: Score comparability and respondent preferences, *Measurement & Evaluation in Counseling & Development (American Counseling Association),* 33, 3, 130.

Wade, M. and Hulland, J. (2004) The resource-based view and information systems research: Review, extension, and suggestions for future research, *MIS Quarterly,* 28, 1, 107-142.

Wadsworth, M. E., Gudmundsen, G. R., Raviv, T., Ahlkvist, J. A., McIntosh, D. N., Kline, G. H., et al. (2004) Coping with terrorism: Age and gender differences in effortful and involuntary responses to september 11th, *Applied Developmental Science,* 8, 3, 143-157.

Walker, N., Philbin, D. A. and Fisk, A. D. (1997) Age-related differences in movement control: Adjusting submovement structure to optimize performance, *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences,* 52B, 1, P40-P52.

Wang, K., Shu, Q. and Tu, Q. (2008) Technostress under different organizational environments: An empirical investigation, *Computers in Human Behavior,* 24, 6, 3002-3013.

Washburn, D. A. (2003) Presidential address: The games psychologists play (and the data they provide), *Behavior Research Methods, Instruments & Computers,* 35, 2, 185-193.

Washburn, D. A. and Gulledge, J. P. (1995) Game-like tasks for comparative research: Leveling the playing field, *Behavior Research Methods, Instruments, & Computers,* 27, 2, 235.

Washburn, D. A. and Gulledge, J. P. (2002) A species difference in visuospatial memory in adult humans and rhesus monkeys: The concentration game, *International Journal of Comparative Psychology,* 15, 4, 288-302.

Washburn, D. A., Gulledge, J. P., James, F. and Rumbaugh, D. M. (2007) A species difference in visuospatial working memory: Does language link "what" with "where"? *International Journal of Comparative Psychology,* 20, 1, 55-64.

Wästlund, E., Norlander, T. and Archer, T. (2008) The effect of page layout on mental workload: A dual-task experiment, *Computers in Human Behavior,* 24, 3, 1229-1245.

Weems, C. F. and Carrion, V. G. (2009) Brief report: Diurnal salivary cortisol in Youth—Clarifying the nature of posttraumatic stress dysregulation, *Journal of Pediatric Psychology,* 34, 4, 389-395.

Weigensberg, M. J., Lane, C. J., Winners, O., Wright, T., Nguyen-Rodriguez, S., Goran, M. I., et al. (2009) Acute effects of stress-reduction interactive guided imagery(SM) on salivary cortisol in overweight latino adolescents, *Journal of Alternative & Complementary Medicine,* 15, 3, 297-303.

Whetten, D. A. (1989) What constitutes a theoretical contribution? *Academy of Management Review,* 14, 4, 490-495.

White, H., McConnell, E., Clipp, E., Branch, L. G., Sloane, R., Pieper, C., et al. (2002) A randomized controlled trial of the psychosocial impact of providing internet training and access to older adults, *Aging & Mental Health*, 6, 3, 213-221.

Whiting, W. L., Madden, D. J. and Babcock, K. J. (2007) Overriding age differences in attentional capture with top-down processing, *Psychology and Aging,* 22, 2, 223-232.

Wierwille, W. W. and Eggemeier, F. T. (1993) Recommendations for mental workload measurement in a test and evaluation environment, *Human Factors*, 35, 2, 263-281.

Wilson, R. S., Bennett, D. A., Beckett, L. A., Morris, M. C., Gilley, D. W., Bienias, J. L., et al. (1999) Cognitive activity in older persons from a geographically defined population, *Journals of Gerontology Series B: Psychological Sciences & Social Sciences*, 54B, 3, P155-60.

Yantis, S. (1993) Stimulus-driven attentional capture, *Current Directions in Psychological Science (Wiley-Blackwell),* 2, 5, 156-161.

Yantis, S. (1993) Stimulus-driven attentional capture and attentional control settings, *Journal of Experimental Psychology: Human Perception and Performance,* 19, 3, 676-681.

Yantis, S. and Egeth, H. E. (1999) On the distinction between visual salience and stimulus-driven attentional capture, *Journal of Experimental Psychology: Human Perception and Performance,* 25, 3, 661-676.

Yantis, S. and Jonides, J. (1990) Abrupt visual onsets and selective attention: Voluntary versus automatic allocation, *Journal of Experimental Psychology: Human Perception and Performance,* 16, 1, 121-134.

Yeh, M. and Wickens, C. D. (2001) Attentional filtering in the design of electronic map displays: A comparison of color coding, intensity coding, and decluttering techniques, *Human Factors,* 43, 4, 543.

Yeh, Y. and Wickens, C. D. (1988) Dissociation of performance and subjective measures of workload, *Human Factors,* 30, 1, 111-120.

Yi, M. Y. and Davis, F. D. (2003) Developing and validating an observational learning model of computer software training and skill acquisition, *Information Systems Research,* 14, 2, 146-169.

Yi, M. Y. and Davis, F. D. (2003) Developing and validating an observational learning model of computer software training and skill acquisition, *Information Systems Research,* 14, 2, 146-169.

Yuditsky, T., Sollenberger, R. L. & Della Rocco, P. S. et al. (2002). *Application of color to reduce complexity in air traffic control.*

Zacks, R. T., Radvansky, G. and Hasher, L. (1996) Studies of directed forgetting in older adults, *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 22, 1, 143-156.

Zacks, R. and Hasher, L. (1997) Cognitive gerontology and attentional inhibition: A reply to burke and McDowd, *Journals of Gerontology Series B: Psychological Sciences & Social Sciences,* 52B, 6, P274.

Zelinski, E. M., Crimmins, E., Reynolds, S. and Seeman, T. (1998) Do medical conditions affect cognition in older adults? *Health Psychology,* 17, 6, 504-512.

Ziefle, M. and Bay, S. (2005) How older adults meet complexity: Aging effects on the usability of different mobile phones, *Behaviour & Information Technology,* 24, 5, 375-389.