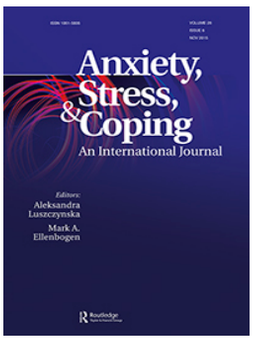

Routledge
Taylor & Francis Group

Anxiety, Stress, & Coping
An International Journal

ISSN: 1061-5806 (Print) 1477-2205 (Online) Journal homepage: http://www.tandfonline.com/loi/gasc20

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To cite this article: Stefan Tams, Jason Thatcher, Varun Grover & Richard Pak (2015) Selective attention as a protagonist in contemporary workplace stress: implications for the interruption age, Anxiety, Stress, & Coping, 28:6, 663-686, DOI: 10.1080/10615806.2015.1011141

To link to this article: http://dx.doi.org/10.1080/10615806.2015.1011141

Anxiety, Stress, & Coping, 2015
Vol. 28, No. 6, 663–686, http://dx.doi.org/10.1080/10615806.2015.1011141

Selective attention as a protagonist in contemporary workplace stress: implications for the interruption age

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(*Received 3 October 2013; accepted 9 January 2015*)

Background and Objectives: The ubiquity of instant messages and email notifications in contemporary work environments has opened a Pandora's Box. This box is filled with countless interruptions coming from laptops, smartphones, and other devices, all of which constantly call for employees' attention. In this interruption era, workplace stress is a pervasive problem. To examine this problem, the present study hypothesizes that the three-way interaction among the frequency with which interrupting stimuli appear, their salience, and employees' deficits in inhibiting attentional responses to them impacts mental workload perceptions, ultimately leading to stress. The study, further, probes a related form of self-efficacy as a potential suppressor of interruption-based stress. **Design:** The study used a 2 (low vs. high frequency) × 2 (low vs. high salience) mixed model design. **Methods:** The 128 subjects completed a test of their inhibitory deficits and rated their mental workload perceptions and experiences of stress following a computer-based task. **Results:** Inhibitory deficits and increased interruption salience can alter the perception of mental workload in contemporary work environments for the worse, but interruption self-efficacy can help offset any resulting interruption-based stress. **Conclusions:** This study extends the literatures on work interruptions as well as on stress and coping in the workplace.

Keywords: interruptions; cognition; stress; selective attention; technology; self-efficacy

Introduction

With the proliferation of such information and communication technologies (ICTs) as instant messages, e-mail notifications, task reminders, Internet telephony, smartphones, and many others, which are all constantly calling for peoples' attention, employees must deal with a dramatic increase of interruptions at work (Cutrell, Czerwinski, & Horvitz, 2001; Jett & George, 2003; Spira & Feintuch, 2005). Turning these interruptions off is often not possible because there are many different kinds of them coming from a variety of ICTs and since turning them off is against the informal norms and formal policies in many organizations. Thus, interruptions in contemporary work environments consume a large part of employees' work days (Spira & Feintuch, 2005), leaving employees saddled with conflict between fulfilling their primary work responsibilities and responding to a plethora of additional queries, questions, and comments. In this interruption age, work

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stress and its implications for employee well-being and performance are pervasive problems (Macik-Frey, Quick, & Nelson, 2007; Riemer & Frößler, 2007). Given these problems, the focus of this research is on interruptions that (1) arise from external, ICT-enabled stimuli such as instant messages or e-mail notifications and that (2) have negative consequences for employees and organizations.

While prior studies have noted the stress-related implications of (external) interruptions (e.g., Jett & George, 2003; Rogelberg, Leach, Warr, & Burnfield, 2006), little is known about the cognitive mechanisms on which interruption-based stress depends and how it can be counteracted. This gap critically limits our understanding of the phenomenon of interruption-based stress because cognition is highly relevant to this phenomenon (Meurs & Perrewé, 2011; Rogelberg et al., 2006). More specifically, interruptions have been suggested to be harmful to the extent to which they disrupt individuals' focused attention on a task (Jett & George, 2003), but past research has discussed this aspect generically without offering insight vis-à-vis the cognitive mechanisms involved. Thus, discovering the cognitive mechanisms at play in the disruption of individuals' focused attention on a task is warranted to enhance understanding of why and for whom (or, under what conditions) the negative consequences of interruptions crystallize.

A particularly pertinent facet of cognition in the context of interruptions and their impacts on peoples' ability to focus on a task is selective attention (Jett & George, 2003), which allows individuals to selectively process some information sources while ignoring others (e.g., it allows individuals to selectively process information about the task at hand while ignoring distracting stimuli; Strayer & Drews, 2007; Zacks & Hasher, 1997). Selective attention helps ensure that individuals are not overwhelmed by all the stimuli that continuously bombard their senses, such as interruptions (Houghton & Tipper, 1994; Strayer & Drews, 2007; Zacks & Hasher, 1997).

The present study addresses the limitation in prior work on interruption-based stress by proposing – on the basis of person–environment fit (P-E fit) theory and theories of selective attention – that selective attention differences among individuals play a crucial role in contemporary workplace stress. More specifically, the study proposes that selective attention differences among individuals can explain why some individuals' stress responses to interruptions are stronger than those of other people. By shedding light on the pertinence of this individual difference, this study details *for whom* work interruptions create stress, an important contribution to (1) the work stress literature as indicated by Cooper, Dewe, and O'Driscoll's (2001) review and critique of stress research, and (2) the literature on work interruptions as indicated by Jett and George's (2003) review and critique of research on work interruptions. Therefore, this study extends and refines the literatures on work stress and work interruptions. This conclusion holds particularly true since peoples' *growing dependence on ICTs* that constitutes the context of this study is considered a factor of key importance to those literatures (Cooper et al., 2001; Macik-Frey et al., 2007). Further, to the best of our knowledge, this research is the first to apply theories of P-E fit and selective attention to the study of the negative consequences of interruptions. Thus, this research may inform further theory based on field studies so that managers can be helped in developing intervention strategies for those employees who would benefit the most from them, making an important contribution to practice (Ganster & Schaubroeck, 1991).

As shown in Figure 1, the present research conceptualizes selective attention patterns as a major threat to employee well-being. It also examines interruption-related self-efficacy beliefs as a possible way to mitigate interruption-based stress. Rooted in the P-E fit

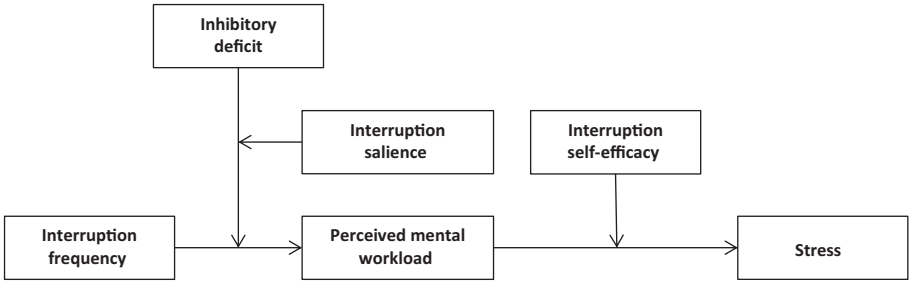

Figure 1. Proposed theoretical model predicting stress responses of workers who encounter frequent interruptions, leading them to perceive high levels of mental workload and ultimately stress.

perspective (French, Caplan, & Van Harrison, 1982) and selective attention theory (Houghton & Tipper, 1994), the research model proposes that the three-way interaction among the frequency with which interruptions appear, their salience,[1] and employees' inhibitory deficits impacts mental workload perceptions, ultimately leading to stress. The model further suggests that managers can counteract the stressful impacts of interruptions by helping their employees develop the belief that they can be successful at their tasks even in the presence of interruptions (i.e., interruption self-efficacy; Bandura, 1997; Lazarus, 1999). Definitions for all constructs in our research model are provided in Table 1.

Refined theoretical development

Framing the phenomenon of interruption-based stress: person–environment misfit

Stress has been defined as a "relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources" (Folkman & Lazarus,

Table 1. Construct definitions.

Construct	Definition
Interruption frequency	Number of interruptions in a given time interval (Jett & George, 2003; Rogelberg et al., 2006; Warburton, 1979)
Interruption salience	Extent to which interruptions appeal to the attentional amplification mechanism because of their color (Houghton & Tipper, 1994; Strayer & Drews, 2007; Wickens et al., 2004)
Inhibitory deficit	Extent to which an individual has difficulty to deliberately suppress the processing of interrupting stimuli so that these stimuli do not gain access to mental resources (e.g., working memory). An inhibitory deficit implies lower selective attention performance (Hasher & Zacks, 1988; Zacks & Hasher, 1997)
Perceived mental workload	Perceived relative balance between the mental resources required to perform a task in a given time (e.g., working memory capacity) and the mental resources available (Hart & Staveland, 1988; Warburton, 1979; Wickens et al., 2004)
Interruption self-efficacy	Extent to which individuals believe in their ability to be successful at their tasks even in the presence of interruptions (Bandura, 1997)
Stress	Extent to which an individual responds to a perceived misfit between resource demands and availability for a task (Folkman & Lazarus, 1984; Lazarus, 1999)

1984, p. 19). Much contemporary stress research follows this view, which implies that stress arises from a perceived misfit between resource supply and demand (Hancock & Szalma, 2008). One key instantiation of this view of stress is the P-E fit perspective (French et al., 1982). This perspective conceptualizes fit/misfit as a perceived relative balance between environmental demands per unit time and a person's mental resources available for responding to these demands, such as calculating, remembering, and deciding (Edwards, Cable, Williamson, Schurer Lambert, & Shipp, 2006; Lazarus, 1999). This relative balance is directly reflected in mental workload perceptions, which increase with such demands as the frequency with which interruptions occur and, in turn, result in stress (Kaldenberg & Becker, 1992; Warburton, 1979; i.e., the "P" in P-E Fit represents a person's mental resource availability, the "E" represents such environmental demands as the frequency with which interruptions occur, and perceived mental workload is a construct reflecting the extent of misfit between "P" and "E" that increases with such environmental demands as interruptions, ultimately causing stress).

PE-Fit theory is consistent with research on work interruptions, which argues that all work roles have primary responsibilities, whose achievement is crucial for effective work performance (Rogelberg et al., 2006). Since interruptions delay effective goal achievement and work performance, they generally have negative implications (Grebner, Semmer, & Elfering, 2005; Jett & George, 2003; Kirmeyer, 1988; Leitner & Resch, 2005; Voydanoff, 2005; Zijlstra, Roe, Leonora, & Krediet, 1999). For example, Zijlstra et al. (1999) found that interruptions negatively impacted well-being due to the time required to restart the execution of the primary task, implying a decrease in task efficiency as well as decreasing motivation and mental fatigue. The authors further explained this finding by suggesting that additional resources are often needed to deal with the additional demands from interruptions. Similarly, Zohar (1999) indicated that when an activity is interrupted, a person must exert greater effort to overcome that obstacle, depleting the cognitive resources that could otherwise have been allocated to the primary task. As a result, people experience more fatigue and negative mood. This notion is consistent with Jett and George (2003), indicating that interruptions impact individuals' focused attention by diverting attention or cognitive resources that could have otherwise been directed to the primary task. In generating this cognitive interference, interruptions place a heavy burden on working memory, potentially leading to such negative psychological experiences as stress perceptions (Jett & George, 2003).[2]

Interruptions have particularly negative consequences when individuals are working on an engaging task (Jett & George, 2003). However, some individuals are more prone to be distracted by interruptions than others; whether a person experiences negative consequences from interruptions while working on an engaging task depends on the person's ability to ignore the interruptions, that is, on the person's selective attention (Jett & George, 2003). The effectiveness of selective attention varies considerably among individuals so that there is substantial variance in how individuals react to interruptions (Jett & George, 2003). Overall, interruptions as distractions result in negative consequences for individual well-being when the task is engaging and requires a person's full attention and when the person has a trait that makes him or her particularly vulnerable to distractions (Jett & George, 2003).

Following PE-Fit theory and research on work interruptions, one could reasonably argue that the frequency with which employees are interrupted in their work may, generally, increase cognitive demands and workload perceptions, ultimately causing

stress. However, the manifestations of mental workload and subsequent interruption-based stress may depend on the extent to which a person's selective attention patterns are inadequate for today's work environments, that is, a person's inadequacy in allocating cognitive resources efficiently among work tasks and interruptions. A large selective attention inadequacy (or inadequacy in allocating cognitive resources efficiently) may imply that work interruptions absorb most of the cognitive resources that a person has available for her work.

An amplifier of person–environment misfit: selective attention inadequacy

Having connected interruption-based stress to human cognition, we now turn to research on selective attention, which is a potentially relevant aspect of cognition in this context. Selective attention refers to peoples' ability to allocate working memory resources for information processing efficiently (Strayer & Drews, 2007). This ability is important because the storage capacity of working memory is limited, at times to as little as one item (Dumas & Hartman, 2008). If interruptions enter working memory, this storage capacity limitation implies that they can quickly and dramatically reduce employees' working memory resources available for completing their primary work responsibilities.

To prevent interruptions from entering working memory, selective attention uses two mechanisms: inhibition (goal-directed) and amplification (stimulus-driven) (Houghton & Tipper, 1994). While inhibition serves to filter out irrelevant stimuli, amplification[3] automatically selects relatively salient stimuli (e.g., reddish stimuli are more salient than gray ones) for receiving working memory resources. For instance, in a grocery store, peoples' attention may be drawn involuntarily to the generic cookie next to a red light (stimulus-driven attention or amplification); yet, the customers may still try to disregard this information in favor of the Oreo-brand cookies they intend to buy (goal-directed attention or inhibition; Christ, Castel, & Abrams, 2008).

In the context of this study, effective inhibition allows individuals to actively disregard interrupting stimuli so that they do not enter working memory and, as a result, do not impact mental workload perceptions. This notion implies that even as the frequency of interruptions increases, mental workload perceptions remain unaffected for individuals with an effective inhibitory mechanism. By contrast, amplification works on interruption salience such that when interrupting stimuli possess such salient properties as reddish colors, they are likely to enter working memory (i.e., stimulus-driven attentional capture) and, thus, to increase mental workload perceptions.

Attentional inhibition and amplification operate in parallel such that the effect of a person's goal-directed attentional control is contingent on stimulus-driven attentional capture. More specifically, effectively inhibiting an attentional response to an interrupting stimulus is an important action when the stimulus is salient and, thus, likely to capture attention and consume working memory resources (Folk, Remington, & Johnston, 1992; Houghton & Tipper, 1994). By contrast, a non-salient stimulus, which is likely to pass by unnoticed, may render inhibition irrelevant. This contrast implies that an individual with an inhibitory deficit (i.e., a stable, trait-like characteristic) can exhibit poor selective attention performance with detrimental impacts on working memory capacity as well as related perceptions of mental workload and stress when interruptions possess such salient properties as reddish colors (i.e., a feature of the interruption).

Consequently, in people with high as opposed to low inhibitory deficits, interrupting stimuli will be more likely to enter working memory and shift the relative balance between available and required mental resources, leading to higher levels of perceived mental workload. Yet, this interaction effect should only occur when the interrupting stimuli are relatively salient so that they are likely to capture attention (see Figure 2). Formally:

> Hypothesis 1. There will be a three-way interaction among interruption frequency, interruption salience, and inhibitory deficit in the prediction of perceived mental workload such that inhibitory deficit will positively moderate the relationship between interruption frequency and perceived mental workload for relatively salient interruptions, and it will be of no significant consequence for interruptions of lower salience.

This hypothesis implies that individuals whose selective attention patterns are not sufficiently adequate to manage the interruptions found in contemporary work environments are subject to person–environment misfit (in the form of mental workload). This misfit can result in stress depending on a person's available coping resources in the form of self-efficacy beliefs (i.e., competency beliefs).

The dependence of misfit-related stress on self-efficacy in an interruption context

P-E fit theory implies that perceived mental workload increases perceptions of stress because it signals an insufficient supply of the mental resources required to meet task demands (Van Harrison, 1985). By signaling the incapability to meet task demands, mental workload perceptions produce feelings of threat, which are expectations of future harm such as losing one's job or status within a community, instantly resulting in stress (Lazarus, 1999). Consistent with this concept, mental workload has long been validated empirically as a major job stressor (Friend, 1982), and it may be an even more important stressor in today's computer-based work environments that place particularly high mental demands on employees (Birdi & Zapf, 1997). However, this impact of mental workload

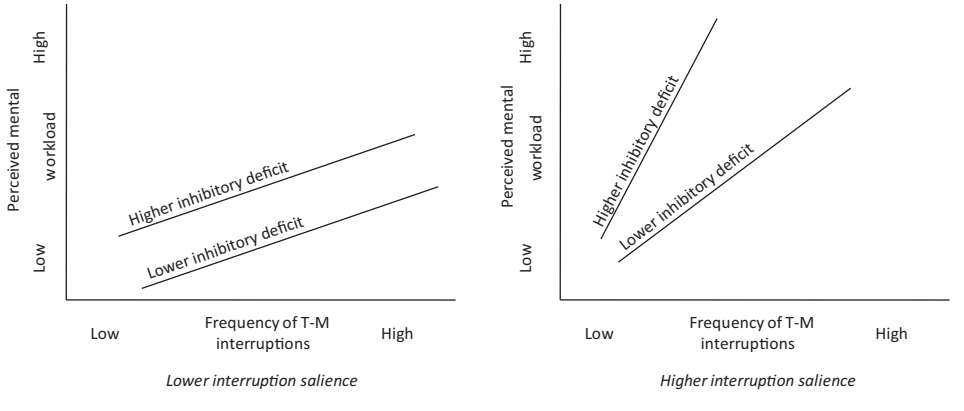

Figure 2. Proposed three-way interaction among interruption frequency, interruption salience, and inhibitory deficit in predicting perceived mental workload.

perceptions may depend on other relevant cognitive states that could help people cope, such as self-efficacy beliefs (Lazarus, 1999).

Self-efficacy beliefs, referring to individuals' beliefs to be successful in certain domains, have been suggested to be major factors in coping with workplace stress (Bandura, 1982, 1997; Lazarus, 1999). Indeed, individuals high in self-efficacy tend to be hopeful and optimistic, feelings that directly counter potential sensations of threat so that task demands present less of a struggle. By contrast, people with low self-efficacy (i.e., self-doubt) are more likely to visualize failure scenarios and to dwell on their personal deficiencies and the harmful consequences of failure. Thus, the latter people should be more affected by stressors (Bandura, 1997; Folkman & Lazarus, 1984). In support of this logic, recent research reports that people with low self-efficacy show more stress in the face of such task demands as work overload than those with high self-efficacy (e.g., Nauta, Liu, & Li, 2010). This analysis suggests that peoples' confidence in their ability to be successful at their tasks even in the presence of interruptions (i.e., interruption self-efficacy) may moderate the impact of mental workload perceptions on stress. Formally:

Hypothesis 2. Interruption self-efficacy moderates the effect of perceived mental workload on stress so that it is weaker for higher levels of interruption self-efficacy.

Method

Procedure and sample

Consistent with influential research on attention (e.g., Kanfer & Ackerman, 1989) and with a significant portion of prior research on workplace interruptions (Jett & George, 2003), a laboratory experiment was conducted. This method was particularly appropriate for the present study for two main reasons. First, the interruption frequency and salience constructs can more effectively be experimentally manipulated than captured through retrospective self-reports of past experiences due to their objective nature. This aspect holds particularly true since asking respondents to recall historical as opposed to current information generally introduces recall errors and reduces reliability (Schwarz, 2007). In particular, retrospective frequency reports (i.e., subjects reporting on the frequency of an experience during a specified time period, such as last week or month) are likely to be inaccurate. The subjects first have to rely on their memory to identify the experience of interest, then review the time period, then retrieve all instances that match the target experience, and finally count these instances to determine the overall frequency of the experience. As Schwarz (2007) points out, respondents can only follow such a recall-and-count strategy under very limited circumstances. Hence, an objective manipulation of these objective states (i.e., interruption frequency and salience) is a more effective strategy for this research than a large-scale survey. Second, a laboratory experiment was essential for the present research to obtain a clear-cut and generally accepted operational index of inhibition, such as the Stroop effect that directly and objectively evaluates subjects' abilities to inhibit interruptions (as elaborated upon below) (Shilling, Chetwynd, & Rabbitt, 2002; Zacks & Hasher, 1997).

The experiment employed a computer-based task, which was an adaptation of the memory game Concentration that has been used in research on cognitive functioning (e.g., Eskritt, Lee, & Donald, 2001; Schumann-Hengsteler, 1996; Washburn, Gulledge, James, & Rumbaugh, 2007). It required the subjects to find matching pairs of symbols in

a matrix by flipping computer-generated cards. In the process, the subjects had to memorize the symbols they had seen and where the symbols were located in the matrix.[4] The task was engaging and elicited motivated performance (Washburn et al., 2007). Additionally, good task performance (i.e., a large number of matching pairs uncovered) was incentivized to increase the relevance of the task for the participants and their involvement above and beyond the intrinsically motivating nature of the task. As a result, the task was particularly engaging, *consistent with theory and research on the negative consequences of interruptions* (Jett & George, 2003).

While the subjects were working on the Concentration task, interruptions in the form of instant messages appeared within specific time intervals on the computer display. Consistent with past research (e.g., Theeuwes, 1991), the subjects were instructed to ignore the interruptions so as to reduce potential confounding effects on the basis of individual differences. This approach, in which we controlled for individual differences in peoples' responses to interruptions, ensured that our study had high internal validity. It allowed us to conclude that any effects of these interruptions were due to differences in inhibitory deficits rather than other individual difference variables.

The experiment included two factors, interruption frequency and interruption salience, with two levels each (i.e., a 2 × 2 design). The subjects were randomly assigned to the different experimental conditions, and interruption frequency (lower and higher) was used as a between-subjects variable. Within each of the resulting two groups, subjects were presented with each of two conditions for interruption salience (higher and lower), with the order of presentation counter-balanced across participants. Immediately following each condition, the subjects rated the amount of mental workload and stress they experienced. The ratings of these two constructs were performed using different kinds of perceptual measures as elaborated upon below in an effort to control common method variance. We recruited 128 subjects by means of bulletin boards and announcements. Of these subjects, 47% were male, and the average age was 46 (*SD* of 25.31). Most subjects were in very good health based on a 3-item measure using 5-point Likert-type scales, a sample item is "How satisfied are you with your present health?" Sixty-four participants took part in each experimental condition in a mixed model design.

Ecological validity

The Concentration task used in this research was designed to be consistent with the work-related context in organizations. For example, concentrated information processing, memory performance, and cognition all lie at the very heart of ICT-based work in organizations (Bensaou & Earl, 1998; Gallivan, Spitler, & Koufaris, 2005; Marakas, Johnson, & Clay, 2007). Table 2 maps the present study onto several dimensions that characterize contemporary work environments. Further, consistent with Mook (1983), the present study is likely to provide us with an understanding of interruption-based stress in organizations even if the task, by itself, does not fully resemble the real world. This argument can be made because the psychological processes uncovered in this study are likely to also operate in the real world. For example, people are likely bounded by their selective attention, working memory, and interruption self-efficacy not only in the laboratory but also in organizations since these traits characterize individuals regardless of the setting in which they act (Bandura, 1997). *Consistent with this argument, prior studies conducted in the field have shown that cognition in general, and memory*

Table 2. Comparison of the organizational context to the study context.

Dimension of comparison	ICT-based tasks in organizations	Concentration task employed in the present study	References
Role of interruptions	Real-world ICT-based tasks are characterized by continuous interruptions such as instant messages, email notifications, task reminders, or message reminders, leaving workers saddled with conflict between fulfilling their primary work responsibilities and responding to a plethora of additional queries, questions, and comments	The Concentration task was characterized by continuous interruptions from instant messages in the high frequency condition	Cutrell et al. (2001), Jett and George, (2003), Spira and Feintuch (2005), and Theeuwes (1991)
Role of working memory and information processing demands	Real-world ICT-based tasks are characterized by extensive working memory and information processing demands due to the complexity of the information involved in such tasks and the fast work pace these tasks tend to implicate	Concentration is an explicit memory task; an extensive amount of information must be held in working memory, and it must be processed effectively to make decisions about what card to flip next	Bensaou and Earl (1998), Darowski et al. (2008), Washburn et al. (2007), and Wickens et al. (2004)
Role of selective attention	Real-world ICT-based tasks are characterized by high demands for selective attention so that attention can be sustained on the display over long periods of time and the task demands can be fulfilled	The task requires that attention can be sustained on the display so that a large number of matching cards can be uncovered in the allotted time. To further increase the task's attentional demands, uncovering a large number of matching pairs within the allotted time was incentivized	Agarwal and Karahanna (2000), Spira and Feintuch (2005), Washburn et al. (2007)
Role of self-efficacy	Self-efficacy exists and operates in the real world, and it has important implications for workplace behavior, well-being, and performance	Interruption Self-efficacy was an important element in this study due to its moderating role on stress	Bandura (1997) and Rogelberg et al. (2006)

Table 2 (*Continued*)

Dimension of comparison	ICT-based tasks in organizations	Concentration task employed in the present study	References
Role of engagement	Real-world ICT-based tasks tend to be both engaging and absorbing such that "the individual's interaction with the technology extends beyond mere instrumentality to be pleasurable and enjoyable as an end in itself" (Agarwal & Karahanna, 2000, p. 668)	The task is both engaging and absorbing; it is intrinsically motivating and enjoyable and, thus, also popular as an online game	Agarwal and Karahanna (2000), Washburn (2003), and Washburn et al. (2007)
Role of the computing environment	Real-world ICT-based tasks typically require that workers sit in front of their computers over prolonged periods of time to fulfill their tasks	The entire task was performed using a computer so that the participants had to sit in front of their computers over prolonged periods of time	Spira and Feintuch (2005) and Washburn et al. (2007)
Role of time pressure	Real-world ICT-based tasks tend to engender substantial time pressure because organizations often allow their workers insufficient time to accomplish their work	The task employed in this study engendered a substantial amount of time pressure since uncovering a large number of matching pairs within the allotted time was incentivized	Ahituv, Igbaria, and Sella (1998), Swanson and Ramiller (2004), and Slone (2007)

ICT, information and communication technologies.

performance in particular, have vital implications for the workplace (e.g., DeNisi & Peters, 1996; Epitropaki & Martin, 2004).[5]

However, to maximize the relevancy of our study for real-world settings, we implemented different strategies in our research design. First, we used prominent incentive mechanisms, such as participant rankings and lotteries, to increase the relevance of the task for the study participants along with their involvement. Second, we selected the task used in the study, the participants, and the measures to be consistent with a significant body of research in the areas of attention, work interruptions, and stress (e.g., Cooper et al., 2001; Jett & George, 2003; Kanfer & Ackerman, 1989; Washburn et al., 2007). Finally, we selected the task based on its considerable relevancy for the workplace, in terms of cognition and workplace conditions (e.g., information processing, working memory, attention, time pressure, engaging nature – please see Table 2 for more details; Gallivan et al., 2005; Marakas et al., 2007).

Measures/manipulations

Interruption frequency

Interruption frequency was manipulated through two levels, lower (i.e., interrupting stimuli appearing every 90 seconds) and higher (i.e., interrupting stimuli appearing every 10 seconds). Manipulation checks confirmed the validity of these 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."

Interruption salience

Consistent with prior research (Strayer & Drews, 2007; Wickens, Lee, Liu, & Becker, 2004), interruption salience was manipulated using color codes. More specifically, the interrupting stimuli appeared in gray color in the lower salience condition and in red color in the higher salience condition. Manipulation checks confirmed the validity of these manipulations. The mean for lower perceived salience was 4.08 (SD = 1.22) on a 7-point scale, while the mean for higher perceived salience was 4.65 (SD = 1.44), a difference that was significant at the 0.001 level. A sample item is "The interruptions were very noticeable."

Inhibitory deficit

Consistent with prior research, inhibitory deficit was assessed through the objective Stroop task (Stroop, 1935; Shilling et al., 2002). The task presents color names printed in non-consistent ink colors, requiring participants to actively inhibit the printed names of the colors, while selectively attending to the ink color in which the words are printed. To illustrate, a subject may have to name the ink color yellow for a word that reads *red* (i.e., the word *red* printed in yellow ink). Since most people have a natural and strong tendency to read, they must inhibit this tendency in order to correctly name the ink color (Shilling et al., 2002). The task yields the Stroop effect, which is the difference in response times between congruent and incongruent color words. The Stroop task has wide support for its

reliability and validity, with test–retest reliabilities ranging from 0.83 to 0.91 (Spreen & Strauss, 1998).

Perceived mental workload

Measures of perceived mental workload should have several important properties, including strong diagnostic capabilities, reliability, and low intrusiveness (Eggemeier, 1988). The NASA Task Load Index (TLX; Hart & Staveland, 1988), a widely used and well-validated measure of perceived mental workload (Cao, Chintamani, Pandya, & Ellis, 2009), has been shown to meet these criteria (Rubio, Díaz, Martín, & Puente, 2004). Above all, the TLX is not perceived as intrusive by subjects (Hart & Staveland, 1988), allowing the researcher to isolate interruption-based stress effects. The TLX is a comprehensive and multidimensional subjective measure of mental workload (Cao et al., 2009), which derives an overall assessment of perceived mental workload from a weighted average of ratings on subscales for mental demand, physical demand, temporal demand, performance, effort, and frustration level. This overall assessment yields a score between 0 and 100 (Cao et al., 2009).

To arrive at the overall workload score between 0 and 100 from the six subscales, the TLX uses a two-step process in which subjects assign both weights and ratings to the subscales (Cao et al., 2009). More specifically, 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). The entire test takes about three minutes to be completed (Hart & Staveland, 1988). The subscales on which the overall assessment is based are presented to the subjects in the forms of six items for mental demand, physical demand, temporal demand, performance, effort, and frustration level, asking the subjects to click on each scale at the point that best reflects their experience of the task (e.g., low vs. high mental demand).

Consistent with prior research (e.g., Fisher & Ford, 1998; Zohar, 2000; Zohar, Tzischinski, & Epstein, 2003), this study used the TLX to evaluate perceived mental workload. Using this scale was further appropriate for this study since – according to Schwarz (2007) – participants can report accurately and precisely on current behaviors and experiences, such as an episode of mental workload or stress they have just experienced (i.e., real-time data capture).

Individual stress

The stress scale employed in this research was an existing scale adapted from the 5-item work exhaustion subscale of the General Burnout Questionnaire (Schaufeli, Leiter, & Kalimo, 1995). The five items ($\alpha = .91$) were measured using 7-point Likert-type scales. A sample item is "I felt stressed from the task demands."

Interruption self-efficacy

To assess interruption self-efficacy, we adapted Banduras' (1997) existing self-efficacy items to our study context. In the process of adapting this measure, we relied on card sorting exercises, pretests, and pilot-tests to ensure good measurement properties. The resulting 3-item measure (using 7-point Likert-type scales; $\alpha = .83$) asked subjects to what extent they are confident that they can perform their tasks effectively even when interruptions are present. To reduce potential confounding effects due to differing individual interpretations of what constitutes an interruption, we provided the participants with examples, such as text messages and instant message pop-ups. A sample item is "I believe I have the ability to be successful at the things I am faced with despite the presence of interruptions.[6]"

Control variables

Consistent with prior research (e.g., McLeod, Griffiths, Bigelow, & Yingling, 1982; Salthouse & Babcock, 1991; Zacks & Hasher, 1997), we controlled for the effects of gender, education, computer-game self-efficacy, processing speed, and short-term memory, and whether the participants were native English speakers, as these variables may be related to perceptions of mental workload and stress. Respondent gender was recorded as male/female, education was measured on an 8-point scale ranging from no formal education to a doctoral degree, and computer-game self-efficacy was assessed through a 3-item measure constructed by following Churchill (1979) and Bandura (1997) ($\alpha = .93$). A sample item for computer-game self-efficacy is "I believe I have the ability to be successful at most computer games I try to play." Further, processing speed was assessed using the digit-symbol substitution task requiring the subjects to substitute as many digits for symbols as possible within a 90-second period, and short-term memory was evaluated by requiring the subjects to remember symbols that correspond to the numbers one through nine over a 90-second period. Finally, whether the participants were native English speakers was recorded on a binary scale.

Results

In correspondence with the study's mixed model design, repeated measures analysis of covariance (RM-ANCOVA) was used to test the study hypotheses. The means, standard deviations, and intercorrelations for the study's variables are presented in Table 3.

Control variables

Consistent with prior research, we employed processing speed, short-term memory, and language abilities as controls for perceived mental workload, and we used gender, education, and computer-game self-efficacy as controls for stress (e.g., Bandura & Locke, 2003; McLeod et al., 1982; Rogelberg et al., 2006; Salthouse & Babcock, 1991; Zacks & Hasher, 1997).

Table 3. Means, standard deviations, and intercorrelations among study variables.

	Variable	*M*	*SD*	1	2	3	4	5	6
1	Interruption frequency	0.50	0.50	–					
2	Interruption salience	0.50	0.50	0.000	–				
3	Inhibitory deficit	73.07	127.88	0.001	0.000	–			
4	Mental workload	54.06	15.63	0.020	0.002	0.089	–		
5	Individual stress	2.31	1.06	0.023	0.015	0.200**	0.421**	–	
6	Interruption self-efficacy	4.92	1.13	−0.116	0.000	−0.138	−0.067	−0.277**	–

$n = 128$.
**$p < .01$.

Hypothesis 1

The continuous predictor variables were mean-centered prior to analysis (Aiken & West, 1991). The RM-ANCOVA indicated a significant interruption frequency × salience × inhibitory deficit interaction effect on perceived mental workload, $F(1, 104) = 4.019$, $p < .05$. Following Aiken and West (1991), the plot of this interaction supported H1 (see Figure 3); the form of the interruption frequency × inhibitory deficit interaction differed depending on interruption salience. Inhibitory deficit did not moderate the relation between interruption frequency and mental workload for interruptions of lower salience ($t = 1.187$, $p > .05$) but only for interruptions of higher salience ($t = 2.410$, $p < .05$, $\eta_p^2 = .06$). More specifically, when salience was low, subjects with higher inhibitory deficits (one *SD* above the mean) reported no significantly larger increase in mental workload

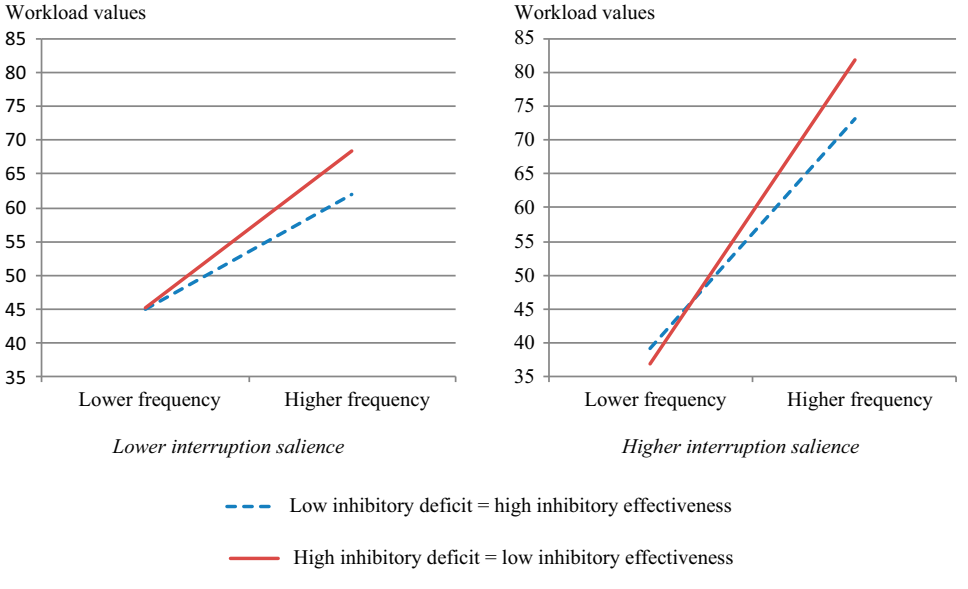

Figure 3. Results for the three-way interaction among interruption frequency, interruption salience, and inhibitory deficit in predicting perceived mental workload.

when interruption frequency increased than did subjects with lower inhibitory deficits (one *SD* below the mean; left portion of Figure 3). By contrast, when salience was high, the relationship between interruption frequency and mental workload was significantly stronger for subjects with higher inhibitory deficits (right portion of Figure 3). In the latter case, the frequency × inhibitory deficit interaction accounted for 6% of the variance excluding other factors, a medium effect size in repeated measures analysis (Cohen, 1988).

Hypothesis 2

The RM-ANCOVA showed a significant interaction effect of perceived mental workload and interruption self-efficacy on stress, $F(1, 109) = 4.106$, $p < .05$, $\eta_p^2 = .04$. The plot of this interaction supported H2 (see Figure 4); the effect of mental workload perceptions on stress differed depending on interruption self-efficacy. For low levels of interruption self-efficacy, workload had a significant impact on stress ($t = 4.26$), while no such impact could be observed for participants with high levels of interruption self-efficacy ($t = 1.22$).

Post-hoc mediation analysis

To evaluate the mediating role of mental workload between interruption frequency and subsequent experiences of stress, we conducted a Sobel test of the indirect effect (Sobel, 1982). The test indicated a significant z-value for the indirect effect, $z = 1.967$, SE = 0.085, $p < 0.05$. The results also showed that there was no direct effect of interruption frequency on stress when perceptions of mental workload were controlled ($p > 0.05$), signifying full mediation.[7]

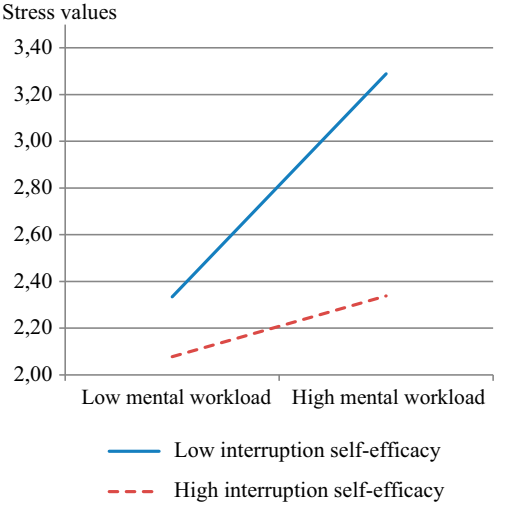

Figure 4. Results for the interaction between perceived mental workload and interruption self-efficacy in predicting stress.

Discussion

On the basis of prior research noting the importance of studying the detrimental impacts of work interruptions (e.g., Jett & George, 2003; Rogelberg et al., 2006), the present research has yielded insight into the cognitive mechanisms on which interruption-based stress depends and how it can be counteracted. More specifically, this study provides initial evidence that selective attention may play a significant role in understanding stress in contemporary work environments. When individuals had a greater inhibitory deficit, interruptions were more likely to enter working memory and shift the relative balance between the mental resources available and required for task performance. This interaction led to higher levels of mental workload and, subsequently, to stress. Yet, this interaction effect depended on interruption salience; an inhibitory deficit was only consequential when interruptions were of higher salience so that they appealed to subjects' attentional amplification mechanisms. Further, interruption self-efficacy served as a pertinent stress-relieving mechanism. These results potentially suggest that people with inhibitory deficits and/or heightened amplification may need to receive particular managerial attention in terms of resources for intervention strategies, such as the resources needed for the development of interruption self-efficacy.

By providing a conceptualization and empirical evaluation of the roles of selective attention and interruption self-efficacy in interruption-based stress, the present study extends the literatures on work interruptions and work stress. Concerning the literature on work interruptions, prior research suggested that interruptions can be harmful to the extent to which they result in a disruption of an individual's focused attention on a task (Jett & George, 2003). Yet, past research has discussed the disrupting nature of interruptions generically, offering limited understanding of the cognitive mechanisms involved. Consequently, this study's discovery of the mechanisms at play in the disruption of focused attention (i.e., selective attention in the form of attentional inhibition and amplification) significantly enhances our understanding of *why and for whom* the negative consequences of interruptions crystallize.

Concerning this study's extension of the stress research literature, Cooper et al. (2001) indicated in their review and critique of stress research that future work should deepen understanding of why stressors may have different impacts on different groups of employees. Consequently, this study's elucidation of the individual differences that explain why some people report more stress than others (i.e., selective attention and interruption self-efficacy) constitutes an important extension of the stress research literature. Additionally, Cooper et al. (2001) suggested that the work stress literature should examine the stressors that are associated with new work arrangements since such contemporary stressors may yield particularly relevant insight into the stress phenomenon. These new work arrangements include today's organizationally mandated and socially desirable use of a plethora of technological devices that constantly call for employees' attention. In fact, individuals' growing dependence on ICTs is considered a factor of key importance for the stress research literature (Macik-Frey et al., 2007). Hence, there is a need to study how technology affects worker well-being and how such well-being can be promoted within our technology-dependent society (Macik-Frey et al., 2007). Consequently, this study's findings vis-à-vis the roles of selective attention and self-efficacy in the stress process that is associated with today's ICT-enabled work environments constitute an important extension of the stress research literature.

Strengths and limitations of the study

This study has several important strengths, most notably the use of a rich and relevant theory base for developing the research model. Although prior research has significantly advanced our understanding of the stress-related impacts of interruptions (e.g., Jett & George, 2003; Kirmeyer, 1988; Rogelberg et al., 2006), such research has failed to combine relevant theories to yield a powerful yet parsimonious understanding of the phenomenon. Hence, this study's integration of P-E fit theory with selective attention and social cognitive theories represents an important improvement in the modeling and subsequent understanding of the phenomenon. Furthermore, the present study employed a rigorous research design that was consistent with its theoretical frame as well as with the extant literatures on attention (Kanfer & Ackerman, 1989), work interruptions (Jett & George, 2003), and related task designs and measurements (e.g., Shilling, Chetwynd, & Rabbitt, 2002; Schwarz, 2007; Washburn et al., 2007).

Still, the results of this research must be interpreted in light of its limitations. First, our binary experimental manipulations may have limited our ability to fully understand the role of selective attention in contemporary workplace stress. Consistent with prior research in the area of cognition, we decided to use two opposed levels per factor (lower and higher) to ascertain rigorous and precise distinctions in our manipulations and to maximize treatment variance (e.g., Elkins, Phillips, & Konopaske, 2002; Gellatly & Meyer, 1992; Kanfer & Ackerman, 1989; Leippe, Eisenstadt, Shannon, & Seib, 2004). Nonetheless, the use of two levels each for interruption frequency and salience represents only two specific instances per factor; more information could perhaps result if one looked at more instances of these factors. For example, future research could investigate the research model proposed here for medium frequencies.

Moreover, although one could attribute our results to common method variance, we used both procedural and statistical remedies to control for method effects (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). We embedded three procedural remedies: the protection of respondent anonymity, the reduction of evaluation apprehension, and the separation of the measurement of the independent and dependent variable pairs. Concerning the latter, it should be noted that interruption frequency, salience, and inhibitory deficit were objective manipulations or tasks, whereas mental workload was a subjective evaluation. While this subjective evaluation of mental workload was, in turn, related to a subjective assessment of stress, both measures were captured through different techniques, the NASA TLX and a 7-point Likert-type scale, respectively. As a result of all these precautions, a Harmon one-factor test (Podsakoff & Organ, 1986), which this study additionally employed, detected no evidence of common method variance. Furthermore, method variance attenuates interaction effects and makes it more difficult to detect them. Hence, the fact that interaction effects were observed in the present study suggests that method variance was not a major threat (Conway & Lance, 2010; Evans, 1985).

Finally, our design approach of asking the subjects to ignore the interruptions might have limited the relevance of our results for the real world. While interruptions as the ones examined here generally have negative consequences (Dabbish, Mark, & González, 2011; Jett & George, 2003; Spira & Feintuch, 2005) and, thus, might best be ignored, there is also a longstanding tradition of research that regards interruptions as a fundamental aspect of modern work, suggesting that being actively responsive to interruptions is an important aspect of knowledge workers' jobs (Mintzberg, 1970).

Furthermore, some recent research has shown that interruptions are often taken immediately rather than deferred to a later time to avoid memory overhead (Wiberg & Whittaker, 2005). Our study does not apply directly to these situations, implying that it has a third limitation. However, we made an effort to mitigate this limitation by considering five important aspects in our study design. First, asking the subjects to ignore the interruptions was consistent with our study conceptualization, and it was necessary to evaluate how well the subjects were able to ignore the interruptions (our measure of the inhibitory mechanism of selective attention). Second, our study was designed to be consistent with prior research on selective attention and cognitive functioning (e.g., Schumann-Hengsteler, 1996; Theeuwes, 1991). Third, the approach taken here increased the internal validity of our study by controlling for individuals differences such as differences in judgment, which could have otherwise created alternative explanations for the identified interaction effects.

Fourth, consistent with Mook (1983), the present study is likely to provide us with an understanding of interruption-based stress in organizations since the psychological processes uncovered here are likely to also operate in the real world (this point is argued further in the earlier section discussing the ecological validity of the study). Further on this aspect, lab experiments can be of substantial scientific value even if they lack ecological validity, particularly if the primary research objective is to test theoretical propositions as opposed to the magnitude of relationships in a specific target population (Berkowitz & Donnerstein, 1982). This research tested novel theoretical propositions. Finally, and perhaps most importantly, our finding that interruptions result in stress *even when they should be ignored* implies that interruptions are likely *even more stressful* when they have to be attended to. In other words, since we found significant stress effects (based on careful theorizing) although the subjects were instructed to ignore the interruptions, there is reason to believe that interruptions will be even more problematic in settings where they are more prominent because they have to be attended to. Thus, our results might be even more relevant for settings in which interruptions cannot be ignored.

Despite the consideration of these five aspects in our study design, we wish to clarify that asking the subjects to ignore the interruptions limits the ecological validity of the study to contexts where interruptions can be ignored (e.g., contexts where interruptions have negative consequences). Hence, future research should examine to what extent our results are applicable to organizational contexts in which interruptions cannot be ignored.

Directions for future research

This study offers important directions for future research since it deepened understanding of the pertinent conditions under which interruption-based stress manifests, a crucial contribution for advancing theory development and testing in this area (Cooper et al., 2001; Jett & George, 2003). Future work could take two interrelated directions to further extend understanding of for whom interruption effects ensue. First, it could deepen understanding of which groups of individuals suffer an inhibitory deficit as well as heightened amplification. Second, it could deepen understanding of how to counter the threats arising from these cognitive patterns through, for example, interruption design and self-efficacy interventions.

Concerning the former direction, future research could identify groups of individuals who suffer from an inhibitory deficit or have heightened attentional amplification since

such people may potentially be especially stressed in contemporary work environments. For example, the inhibitory deficit theory of cognitive aging (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008; Hasher & Zacks, 1988) proposes that older adults are more bothered by distractions than younger due to an impaired inhibitory mechanism. Older people also tend to be more affected by salience such as high-intensity colors or lights (Fisk, Rogers, Charness, Czaja, & Sharit, 2009). Hence, older people may suffer particularly strongly in today`s interruption era. Similarly, people with depression have been suggested to suffer an inhibitory deficit (Houghton & Tipper, 1994), implying that their encounters with salient interruptions may be particularly problematic. These ideas could be further developed and empirically examined in future work.

To counter the threats arising from impaired inhibitory control or strengthened attentional amplification, there are at least two possible ways: reducing the salience with which interruptions appear or increasing interruption-based self-efficacy beliefs. Concerning the former, future work could identify other relevant aspects of salience not examined here. Since this study was among the first to examine the role of salience in interruption-based stress, it focused on one operational definition of salience (i.e., color code). This focus was important to clearly delineate the role of color code in the interruption-based stress process, and it was appropriate since theory on attentional amplification does not suggest that different aspects of salience are differentially effective in capturing attention (e.g., Strayer & Drews, 2007; Wickens et al., 2004). However, it is still possible that other aspects of salience, such as whether the interrupting stimulus appears with flashing, with an aural alert, or moves across the display, may show weaker or stronger interactions with frequency and inhibitory deficit than color code exhibited. Hence, examining the impacts of these other aspects of salience may be a productive avenue for future research. Such research could result in a more detailed understanding of the roles of salience and attentional amplification in the stress process. Concerning the stress-relieving impact of interruption self-efficacy, research could examine how such self-efficacy beliefs can be developed, for example, through well-designed training interventions (Bandura, 1997).

Practical implications

Since the present study was designed to be consistent with prior research on attention and work interruptions (Jett & George, 2003; Kanfer & Ackerman, 1989; Washburn et al., 2007) as well as with contemporary ICT-based work environments (please see Table 2), it has two important implications for practitioners. First, managers must be aware that such interrupting stimuli as instant messages or email notifications may impact employee well-being, particularly for those employees who suffer an inhibitory deficit and heightened attentional amplification. Training that builds interruption self-efficacy may help alleviate this problem. Similarly, training or corporate policies emphasizing the restricted use of email notifications, instant messages, and related technologies on the job may boost employee well-being. For example, such initiatives could encourage employees to group interruptions so that several of them can be processed together. Second, since salience has been shown here to be an important element in the stress process, managers may want to dampen the use of salient display features for interruptions or use them to demarcate interruptions based on priority (e.g., red color use only for particularly urgent and important interruptions like an exception report generated due to a significant drop in sales).

Conclusion

Recent technological developments have created an interruption-intensive environment that will likely get worse as the number of devices proliferates. Since cognition is pertinent in this context, it appears crucial to improve understanding of the cognitive mechanisms on which the negative outcomes of interruptions depend and how they can be alleviated. Our report showed that interruption frequency interacts with attentional inhibition and interruption salience to impact mental workload and ultimately stress. We further found that interruption self-efficacy can counter this interruption-based stress. Hence, we believe that we have taken an important step toward highlighting the cognitive mechanisms at play. Given the high incidence of interruptions in today's work arrangements, we hope that this study will lead to more work in this area to help reduce workplace stress.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes

1. In this study, interruption salience is conceptualized and operationalized in accordance with selective attention theory as an objective state of the interruption rather than a subjective evaluation of the individual. Further, while salience can be visual, auditory, or sensory in nature, this study focuses on the visual facet of salience to isolate its effects within our broader research model; it is assumed that most ICT-based interruptions use visual features.
2. While interruptions can be positive in nature, this study focuses on the negative implications of unwelcome interruptions due to their dominant impact on employee well-being and performance (Macik-Frey et al., 2007).
3. Attentional amplification is also referred to as a "spotlight" (Houghton & Tipper, 1994, p. 59) since – like the beam of a spotlight – it directs attention toward relatively salient stimuli, impacting selective attention efficiency.
4. Please see Schumann-Hengsteler (1996), for a detailed description of this task.
5. Please also note that Colquitt (2008) called for more submissions of laboratory experiments to the *Academy of Management Journal* so that causality can be effectively demonstrated using, for example, puzzles as the one employed here (Colquitt, 2008, p. 620), proofreading, Lego construction, juggling, and so on.
6. While it may seem intuitively plausible that interruption self-efficacy and inhibitory deficit are related, the data did not support this idea. The correlation between the two variables was small and nonsignificant ($r = -0.14$, $p > 0.05$).
7. We additionally conducted post-hoc mediation analyses using the bootstrapping procedure developed by Preacher and Hayes (2008) since the Sobel test may yield underpowered estimates of the intervening effect (Preacher & Hayes, 2008). The results from the bootstrapping procedure were consistent with those obtained from the Sobel test.

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