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THE ROLE OF AFFECT STATE

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TOWARD A FRAMEWORK FOR ALLEVIATING TECHNOSTRESS:

THE ROLE OF AFFECT STATE

A DISSERTATION APPROVED FOR

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Dedication

To The Holy Trinity, Who Is Always With Me, snow, rain, or shine.

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There is no such thing as a self-made man. What we become or what we accomplish is made possible by the support, guidance, and contributions of the people around us.

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ABSTRACT

The objective of this dissertation proposal is to design a general framework for interventions aimed at alleviating the impact of technostress, that is, stress occurring when individuals use information technology (IT) devices. Initially noted as a modern disease of adaptation due to the inability of individuals to cope with IT, technostress is increasing in scope and becoming a serious health concern. IT use has generally enhanced individual and workplace productivity but is creating high levels of technostress among individuals, reducing their task performance, and leading to long-term health consequences. High levels of stress directly impact a person's health and is a demonstrated risk factor for anxiety, depression, and cardiovascular diseases, as well as for diabetes and obesity, because stressed people crave for food high in sugar and fat.

Researchers have recognized technostress, alerted us to its detrimental effects on health, identified specific stressors, such as interruptions through pop-ups, but research has not fully addressed methods that can be enacted by *individuals* to alleviate technostress. Furthermore, affect, although mentioned as an important factor in stress, has not been investigated as regard to technostress. Using the findings on the interplay between affect and stress in the neurophysiology literature, our study addressed this gap by investigating the role played by individuals' affect state in shaping their response to a stimulus. Hence, we propose a framework that integrates the biological underpinnings and the psychological processes of stress and set affect as an important construct in this framework. We posit that the user's affect can be leveraged to minimize the negative effects of episodic stressors during their interactions with technology. In this proposal, *affect* is defined as a neurophysiological state resulting from the evaluation by individuals of a specific stimulus to which they are exposed, and we focus on stimuli occurring during an individual's interaction with technological devices. A stimulus evaluated as bad will result in a negative affect state, while a stimulus assessed as good will result in a positive affect state. *Feeling* is the conscious experiencing of an affect state.

Affect state can impact the individual's attention scope, cognitive flexibility, and appraisal of stimuli that arise from their environment. Based on the neurophysiological underpinnings of stress, we posit that an individual's affect state is a moderator of the relationship between exposure to a stimulus and the appraisal processes of that stimulus. More specifically, users in a positive affect state are less likely to assess a stimulus as distressful compared to their counterparts in a neutral or negative affect state (primary appraisal). Moreover, if the stimulus is appraised to be a distressful stimulus, users in a positive affect state are more likely to appraise the distress as controllable (secondary appraisal) and adopt a more effective coping strategy compared to their counterparts in a neutral or a negative affect state. Proceeding from these observations, we present a framework that emphasizes the roles played by affect state, appraisal, and coping strategies in the stress process, and how affect influences both appraisal and coping to shape an individual's response to a stimulus.

To test our hypotheses, we conducted an online randomized controlled experiment with individuals at least 18 years old recruited from a university campus. During the experimental session, we induced specific affect states in the participants at the beginning of the session, and then ask them to perform a cognitive task on a computer while they are being exposed to frequent pop-up messages, which are identified in prior IS research as stimuli that could create technostress. There were three experimental groups reflecting three different induced affect states (positive; negative; or neutral). These affect states were induced by asking the participants to look at pictures selected

the from the Nencki Affective Picture System (NAPS; Marchewka et al. 2014) that have been demonstrated to induce different affect states.

Technostress being a biopsychological response, we used a combination of perceptual and physiological measures to record the participants' response to the experimental stimuli. The perceptual measures included questionnaires of affect, cognition, and stress appraisal. The physiological measures consisted of participants' facial expressions.

Our study found that positive affect state was associated with appraising pop-up messages as less of a threat compared to negative affect state. Also, individuals in the positive affect condition appraised the pop-up messages to be more controllable and were more likely to adopt adaptive coping strategies (positive reframing, planning, and active coping) compared to participants in a negative affect state. Finally, participants' task performance was influenced by the type of coping strategies they had adopted to deal with the pop-up messages, with support seeking and maladaptive coping being associated with lower performance scores.

Our research contributes to the emergent science on technostress by suggesting methods to alleviate impact of stressors, and provides guidelines for managing technostress to individuals and public policy makers. From a theoretical standpoint, we propose a framework that incorporates the biological mechanisms of stress and addresses the role of affect in shaping the stress response. From a methodological perspective, we use a combination of perceptual and physiological methods to gauge individuals' stress response, demonstrating the value of non-invasive methods such as facial expressions as objective tools for measuring individuals' responses to episodic stressors.

1. BACKGROUND

The concept of *technostress*, now a key topic of research in Information Systems (IS) (Raghu-Nathan et al. 2008; Ayyagari et al. 2011; Galluch et al. 2015) was first introduced by Brod (1982; 1984) who described it as "a modern disease of adaptation caused by an inability to cope with new computer technologies in a healthy manner". It is worth emphasizing the two keywords in this definition: *adaptation* and *cope*. The introduction of new technological devices in one's environment requires an individual to make specific affective, cognitive, and/or behavioral adjustments in order to *adapt* to the "new" environment that emerged from the introduction of these devices. An inability to *adapt* or to *cope* with the changes may engender a psychological strain within the individual and negatively alter their perception of the technology. The consequences of this failure to adapt are reflected in Weill and Rosen's (1997) definition of technostress as "any negative effect on human attitudes, thoughts, behaviors, and psychology that directly or indirectly results from technology" (p. 5).

IS researchers have pursued the topic and identified events in our interactions with technology that lead to technostress in employees during their work. These incidents include system breakdown, employees having to learn new technical skills, slow response time, interruptions through pop-up messages, ads, or emails - referred to as episodic stressors (Trimmel et al. 2003; Riedl et al. 2012; Tams et al. 2014, Galluch et al. 2015). Episodic stressors are incidents that are transient and of relatively short duration, from a few seconds (e.g. pop-up ads, slow response time) to a few hours (e.g. system breakdown). Technostress leads to adverse psychological, behavioral, and physical symptoms, while taking a toll on employees' well-being through negative job-related outcomes, including decreased job satisfaction and task performance (Ragu-Nathan et al. 2008; Tarafdar et al. 2010; Riedl 2013). While IS researchers have focused on technostress and its causes in recent years, biology and health researchers have studied human stress for a long time and have developed an extensive body of knowledge on this topic (Selye 1950; McEwen 2007; Lovallo 2016). From this research, it is evident that the cumulative effects of daily stressful episodes, often referred as episodic stressors in IS research, eventually result in a state of chronic stress with deleterious health effects (McEwen 1998), including weakened immune system (Padgett and Glaser 2003), cardiovascular lesions (Steptoe & Kivimäki 2012; Meng et al. 2018), depression (Hammen 2005), and eating disorders (Torres and Nowson 2007). It is thus of critical importance for organizations to address technostress, for the overall performance of the organization and for the health and well-being of their employees.

1.1 Perspectives and Models of Technostress

How a stimulus generates a stress response in an individual has first been explored by different fields of biology and social sciences. Technostress research in IS draws from other disciplines such as psychology which sets itself to examine the psychological intricacies of stress response since the 1950s (Cooper & Dewe 2004) and management, where job stress has been widely studied (Cooper et al. 2001). One of the first models of stress that was proposed and is extensively used in IS research is the transactional model of stress and coping (TMSC; Lazarus & Folkman 1984). As per this model, the extent to which stress is experienced by an employee depends on the individual's appraisal of the stressor. Thus, a noted stressor could lead to more alertness and task engagement, that is, a *eustress* situation. A stressor creates a *distress* situation when it negatively impacts the individual's well-being and performance. A stressor leads to eustress rather than distress only when the individual appraises the stressor to be a surmountable challenge, rather than a burden preventing them from achieving their goals (Lazarus 1999). Hence, how the individual appraises the stimulus is key to how they respond to it. The same stimulus could be appraised differently, and as we elaborate later, we propose that an individual's affect state plays a significant role in the appraisal process, and ultimately in shaping the nature and magnitude of the stress response.

Likewise, a technological stimulus can lead to a situation of techno-distress or to one of techno-eustress according to how the individual has appraised the stressor (Tarafdar et al. 2019). However, in the current research in technostress, only techno-distress has been extensively studied. This may be due to the fact that Brod's (1984) original definition of technostress as "a modern disease of adaptation caused by an inability to cope with new computer technologies in a healthy manner" encompasses techno-distress only. Literature on how techno-stressors can lead to enhanced performance is scant (e.g. Heikkilä et al. 2015). Consequently, the following literature review of technostress is rather one-sided and focuses exclusively on techno-distress.

What qualifies as techno-distress can be difficult to define empirically. Technology is so intertwined in today's job routines that disentangling its negative effects from the ones of other job-related factors is often impractical. For instance, a work-related stress endured by a computer programmer who spends long night hours debugging a code may not be different in nature from the stress experienced by a truck driver on a night trip who has minimal interaction with an ICT device. Although ICT devices and stress response are two required ingredients for observing techno-distress, the mere existence of work related stress or heavy use of ICT in a job is not a sufficient condition for establishing techno-distress. Technostress concerns the rapport of the individual with the technology, that is, it can only occur within the framework of a human-technology interaction. The quality of the interactions will shape the user's attitude, belief, and behavior towards technology. Hence, it is worthwhile looking into models of Human-Computer Interaction (often now referred as Human-Technology Interaction -HTI) to delineate the occurrence of technostress at work and pinpoint the focus of technostress investigated in this study. Therefore, we use the three-level framework proposed by Eason (1991) to describe HCI-related issues can be used to typologize the multiple facets that technostress can present. See Figure 1.

1.1.1 Techno-distress at Level 1 of Eason's HCI Model

The first level (Level 1) in this framework involves only the individual user (human), the computer, and the interaction that exists between these two entities. This interaction is conceived as a simple conversation between two units that have the ability to process information. Technological features or events and individual user characteristics that hinder the flow of the interaction can give rise to technostress. For instance, system breakdown, slow response time when navigating on the web, and frequent interruptions by pop-up messages, by preventing a smooth exchange between the user and the device, can be sources of strain. These are the stimuli often referred in IS research as episodic stressors and studied widely (Galluch et al. 2015; Neben & Schneider 2015). At this level of HCI, technostress can manifest itself as irritation or full-blown anger when the computer does not perform the submitted task, or does not return the output expected by the user.

1.1.2 Techno-distress at Level 2 of Eason's HCI Model

The second level (Level 2) extends HCI to include the characteristics of the user, the task, and the physical environment in which the task is performed. Computer visual displays, keyboards, mouse, tactile screens, and audio outputs, among others, are part of the physical environment. A strained HCI stemming from an inadequate physical environment can lead to backache, neck pain, strained eyes, or wrist pain (Hünting et al. 1981; Läubli et al. 1981). Also, evening or late-night exposure to the blue light emitted by ICT devices screens has been found to cause sleep disorders and insomnia due to the interference of such exposure with the production of melatonin, a hormone responsible for the body circadian rhythm (Chang et al. 2015). These sleep disturbances are likely to cause tiredness, lack of focus and attention, and heightened levels of stress during daytime working hours.

The job characteristics model of work motivation proposed by Hackman and Oldham (1976) identifies five tasks characteristics that influence individuals' experience of the job they perform. These characteristics include skill variety, i.e. the extent to which the task requires the use of a variety of skills and knowledge of the person; task identity, i.e. the extent to which the job involves performing a task from start to end, with the person experiencing the whole process; task significance, i.e. the extent to which the task is of great importance for oneself, other people, or the organization; task autonomy, i.e. the degree to which the task allows a certain degree of independence and discretion; and finally, the existence of a feedback on the individual's performance on the task (Hackman and Oldham 1976). The extent to which the ICT device or computer system espouses these task characteristics and provides the user with all the functionalities that match these features, HCI will be enhanced. For instance, empirical data showed that the average score of task characteristics as defined by Hackman and Oldham's (1976) model, was positively associated with users' flow, i.e., concentration and enjoyment in performing their job while using a computer (Ghani and Deshpande 1994).

1.1.3 Techno-distress at Level 3 of Eason's HCI Model

Finally, the third level (Level 3) of the HCI framework model proposed by Eason (1991) extends the interaction to organizational and social structures. Hence, negative impacts of ICT devices at the organizational and societal levels can qualify as Level 3 techno-distress. For instance, in terms of organizational structures and processes, the widespread use of computers has introduced new modalities of interactions among organizational members with virtual teams and meetings; heavy reliance on emails rather than face-to-face interactions; and an around-the-clock access to employees through text messages, emails, or cellular phone calls. Although some of these changes have resulted in increased productivity, they have engendered concerns for workers well-being and quality of life. Indeed, having a healthy balance between work and life schedule has become more challenging for some workers since requests can be sent to them outside office hours and/or some of the job-related tasks can be performed at home on these devices. The increasingly blurred line between work time and family life has even motivated the French authorities to pass a law affirming employees' right not to get contacted for work purposes by employers or supervisors outside office hours ("right to disconnect") (Ministère du Travail 2017).

A societal impact of the widespread adoption of IT is the effect on hiring practices and job safety net. Indeed, the geographical flexibility provided by the ICT devices in performing organization daily operations have led companies to hire employees working remotely in an effort to tap into a pool of skilled workers who may not be available locally. Also, organizations have resorted to job outsourcing to cut business operations costs (Tate et al. 2009). These new business trends have had societal impacts, including discontent in areas hit by rising unemployment rates perceived to be the result of job outsourcing. The emergence of the so-called *online gig economy* (the use of temporary workers rather than fulltime employees to perform specific jobs in an organization) has brought concerns about employee exploitation since workers in the gig economy often have low wages, poor or inexistent health and retirement benefits, and are not covered by the protections offered by labor unions (Friedman 2014; Graham et al. 2017).

Altogether, a definition of techno-distress that encompasses all three levels of the HCI framework is that of an adverse phenomenon stemming from "***direct human interaction with ICT, as well as perceptions, emotions, and thoughts regarding the implementation of ICT in organizations and its pervasiveness in society in general***" (Riedl 2013).

In the current proposal, as mentioned earlier, we focus on techno-distress at Level 1 of HCI, more specifically episodes in which the user is distressed by technological stimuli such as popup messages, slow response time, or system breakdown while interacting the computer. Such stimuli, thereafter episodic stressors, because they interfere with the user's goal of completing a specific task on the computer, are often appraised as a threat and can trigger a stress response (Riedl et al. 2012; Galluch et al. 2015)

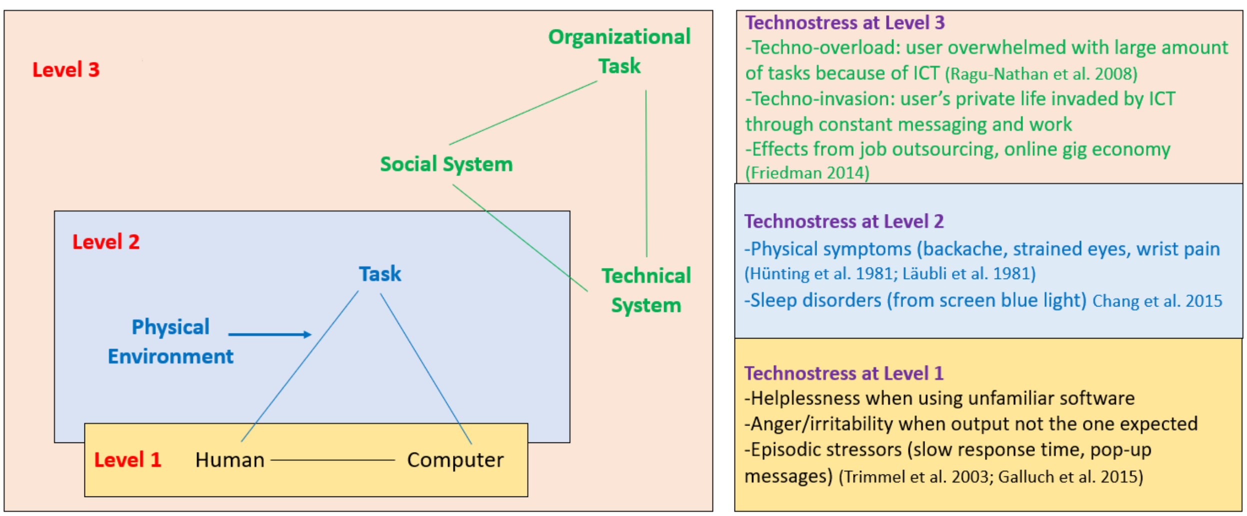


Figure 1: Three-level framework of human-computer interaction (Eason 1991) and techno-distress

1.2 Technostress in the Information System Literature

While stress has been a topic of research in other scientific disciplines for decades, only recently has technostress become a point of interest in IS. Two streams of technostress research have emerged in IS, based on how the investigators describe the stress process and the type of techno-stressor being examined: one in which technostress is depicted as a psychological response to being exposed to a stimulus, and the other where technostress is described as a biological response to a stimulus. The first stream of research (technostress as psychological outcome) has focused mostly on technological stressors in organizational settings, that is technostress at Level 2 or Level 3 of Eason's HCI model (Tarafdar et al. 2007; Ragu-Nathan et al. 2008; Tarafdar et al. 2010;

Ayyagari et al. 2011), while the second stream concentrated on episodic stressors (e.g. system breakdown, interruptive pop-up messages), that is, at Level 1 of Eason's model (Riedl et al. 2012; Tams et al. 2014; Galluch et al. 2015). The two streams of technostress research in IS are detailed below.

1.2.1 Technostress as a psychological process

The IS field has borrowed stress theories from other disciplines in its investigations of technostress. The implied assumption is that technostress is different from other forms of stress only by its context and its triggering factors. Overall, these theories describe stress either as arising from an individual appraising a stimulus to be a hindrance for achieving their goal; or as resulting from an imbalance in the relationships between individual characteristics and environmental or contextual demands. Such imbalance causes a psychological strain likely to persist if the individual is unable to cope or if no action is undertaken to correct the imbalance.

Ayyagari and coauthors (2011) have used the *person-technology fit model* (derived from the person-environment fit model) as a theoretical framework to investigate and identify the specific aspects of ICT that might be involved in the genesis of stress. According to the person-environment fit model, stress arises from the strain imposed on an individual when the characteristics of that individual do not match those of the environment (Edwards 1996; Kristof 1996). Likewise, the *person-technology fit model* describes technostress as stemming from a mismatch between the user's characteristics and the computer (or the computerized environment) during their interaction. Ayyagari and colleagues (2011) described in three categories the technology characteristics that may be involved in technostress: the usability characteristics which include the usefulness, complexity and reliability of the technology; the intrusive characteristics, that is, the extent to which an individual become easily reachable through the technology; and the dynamic characteristics, which reflects the pace of change in the technological tool or environment.

As stated earlier, the most commonly used theoretical framework to study technostress is the *Transactional Model of Stress and Coping* (TMSC), a general model describing stress as emerging from a maladaptive response to stressful stimuli (Lazarus & Folkman 1984). The range of available resources at the individual and organizational levels for addressing the stressful stimuli and the extent to which the employee uses these resources for coping are thought to moderate the relationship between the stimuli and the individual's response. These moderators determine the magnitude and persistence of the stress response. Raghu-Nathan and coauthors (2008) described two sets of factors that could either create or prevent technostress in an organizational context. The stressors were defined as a second-order five-dimensional construct that includes technological *overload* (user overwhelmed with the large amount of tasks or the required high speed occasioned by ICT); *invasion* (user's private life invaded by ICT through constant messaging and work); *complexity* (when the level of sophistication of ICT outmatches the user's skills and knowledge), *insecurity* (when the user is unsecure about keeping their job because of the automation provided by ICT or because they do not possess enough ICT skills); and *uncertainty* (frustration engendered by the constantly changing ICT platforms and functionalities, with needs for training and skills upgrade). The resources (or stress inhibitors) included the availability of IT support within the organization; the availability of IT training and education resources for employees; and the involvement of the personnel in IT-related matters. The empirical data, however, did not provide evidence for the moderator effect of these resources on the link between technostress creators and job satisfaction, although resources were found to have a direct positive effect on job satisfaction and organization commitment.

1.2.2 Technostress as a neurobiological outcome

Stress has been a point of interest in biology and in medicine because of its impacts on the functioning of many body organs and on health outcomes (McEwen 2000a). These research efforts have generated a body of knowledge on the physiological mechanisms that underly the stress response. Understanding the biological underpinnings of stress is necessary not only for evaluating, preventing, and treating its effects on health, but also for detecting stress itself when it arises. Indeed, stress responses are often generated unconsciously as classical conditioned responses acquired through prior exposure to stressors (Lovallo 2016). In such situation, the use of a self-report instrument for detecting a stress response will be of a poor sensitivity since the individual will not be aware of these unconscious stress responses.

Given that technostress is also a form of stress response, and thus a psychosomatic phenomenon, it is fitting to examine the biological mechanisms involved in its occurrence. Two biological systems are involved in the physiology of stress: the hypothalamus-pituitary-adrenal (HPA) axis and the sympathetic-adrenal-medullary (SAM) system. See Figure 2.

The physiology of stress responses revolves mainly around the activation of the HPA axis (McEwen 2000b; Smith & Vale 2006). A stressful stimulus triggers a release of the corticotropin-releasing hormone (CRH) by the paraventricular nucleus of the hypothalamus. Once released, CRH will activate the secretion of the adenocorticotropic hormone (ACTH) by the anterior pituitary gland. Finally, transported through the bloodstream, ACTH will trigger the release of cortisol by the cortex of the adrenal glands. Cortisol is directly responsible for the physical manifestations occurring during stress with an increase in heart rate and a constriction of blood vessels. An important feature of the HPA axis is the existence of a negative feedback loop between the level of cortisol and the release of CRH by the hypothalamus. A high level of cortisol in the bloodstream causes a decrease in CRH release by the hypothalamus, resulting in a decrease in the secretion of cortisol by the adrenal glands. In studies of stress, salivary cortisol is often used as a biomarker of the activation of the HPA axis (Hellhammer et al. 2009; Smyth et al. 2013).

The SAM system includes a set of sympathetic nerves and the medulla of the adrenal glands. This system reacts to the stressful stimulus by releasing adrenaline and noradrenaline. The activation of the SAM system is responsible for a quicker *fight-or-flight* reaction. In studies of stress, salivary alpha-amylase, a salivary enzyme which release is triggered by sympathetic activation, is often used as a biomarker of the activation of the SAM system (Nater & Rohleder 2009).

Relatively few studies in IS have explored the neurobiological dimension of stress encountered by individuals in the context of technology usage. The large majority of these studies which have examined the biological underpinning of technostress have used biochemical markers to measure the stress response. In an experimental study, Riedl and colleagues (2012) reported an increase in salivary cortisol during a system breakdown. Similarly, Tams and coauthors (2014) observed higher levels of saliva alpha-amylase, a biomarker of stress, in study participants receiving interruptive messages at a high frequency during a game session compared to their counterparts receiving the same messages at a lower frequency. Other biomarkers used to examine technostress include adrenaline and noradrenaline, also called epinephrine and norepinephrine (Johansson & Aronsson 1984; Korunka et al. 1996); prolactin (Berg et al. 1992; Arnetz 1996; 1997). See Fischer and Riedl (2015) for a synopsis of biological parameters used in technostress studies.

However, these biochemical markers of stress are very sensitive to physiological, behavioral (Garde et al. 2009), and even postural changes (Hennig et al. 2000), in addition to hourly variations in their levels due to the circadian rhythm of their secretion (Kalsbeek et al. 2012). Because of these limitations, a researcher on technostress has less flexibility in measuring stress response with biochemical markers given all the precautions that should be taken to avoid any confounding factors when collecting the data. Furthermore, it is not feasible to capture with biochemical markers the instantaneous response of an individual exposed to an episodic stressor. Recently, methods that allow to measure the fast biophysical and neurophysiological changes induced by the stress response are being used increasingly in research. These methods include the electroencephalography (EEG), electrocardiography (ECG), electro-dermal activity (EDA), and changes in pupil diameter (Giannakakis et al. 2019). These tools allow to record in real-time the response of an individual when exposed to a stimulus, and thus, are more apt than biochemical markers to capture the effects of repetitive episodic stressors on the person. Only recently has IS research started using these biosignals recording tools (i.e. ECG, EDA etc.) to investigate technostress (Fischer et al. 2018; Baumgartner et al. 2019).

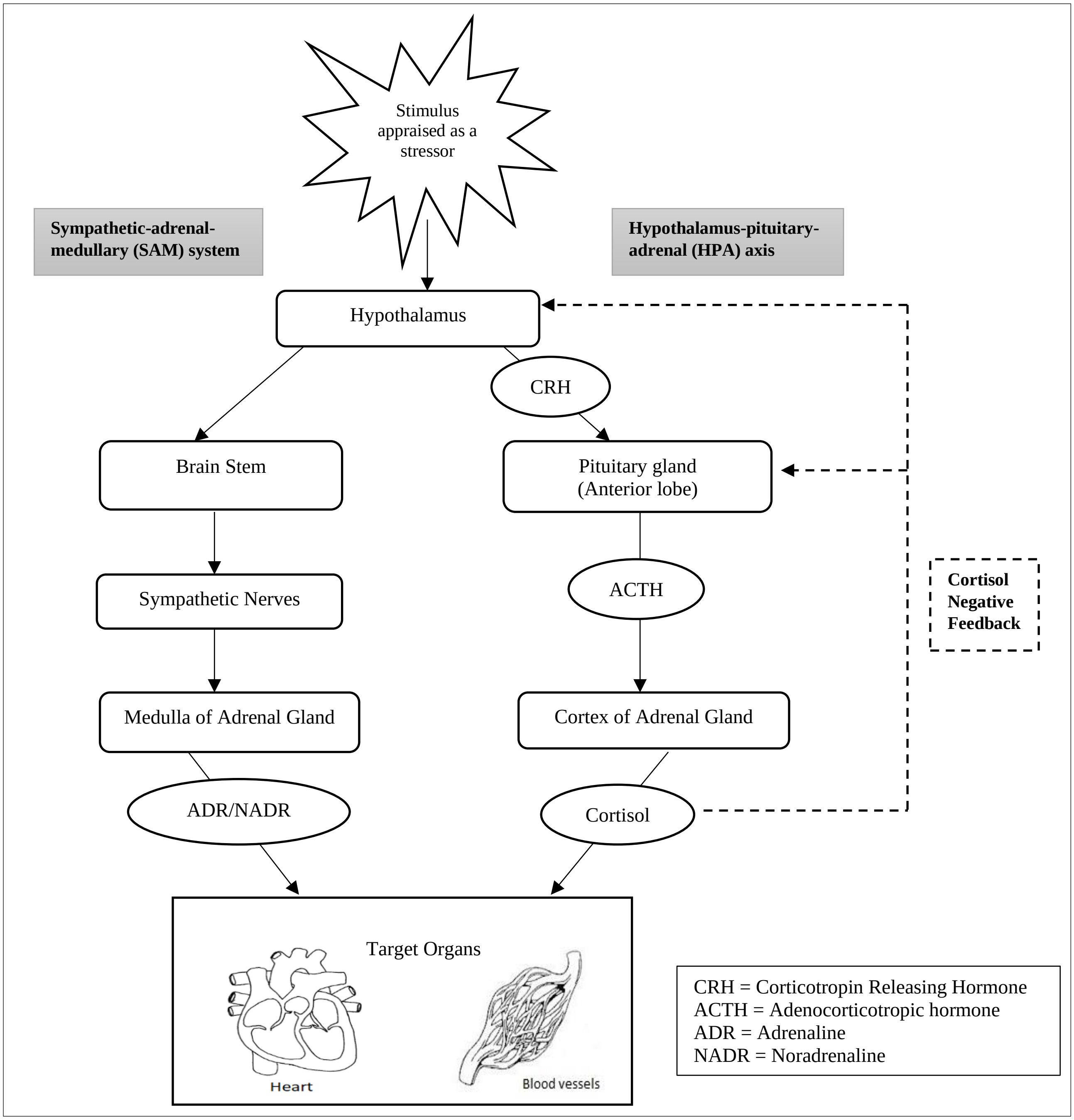


Figure 2: Neurobiological systems of stress response

1.3 Towards the alleviation of techno-distress

As described above, the physiological processes that underly the stress response are normal biological responses that prompt the individual to adapt to their environment or extract themselves from the environment when adapting to it or modifying it is not possible. However, these biological responses are, on the long run, responsible for wear and tear of organs and for many pathologies (McEwen 1998). As mentioned above, the health consequences of stress are pervasive, including depression (van Praag 2004; Hammen 2005), impaired immune system and increased susceptibility to infections (Godbout and Glaser 2006), heightened risk for hypertension (Spruill 2010), stroke (Booth et al. 2015) and coronary heart disease (Kivimäki et al. 2006). It is thus imperative for individuals to minimize the occurrences of these stress episodes if one wants to avoid their negative health impacts.

Given these health risks associated with stress, it is fitting to examine how one may proceed in preventing a stress response from being initiated. One obvious solution is to eliminate or prevent the stressor from occurring in the first place. Methods for reducing the occurrence of techno-stressors include technological improvement of ICT devices (e.g. decreasing response time, creating user-friendly applications) and organizational measures for providing technical to support to employees and enhancing their computer self-efficacy. However, there are situations when it is not feasible to eliminate or prevent the stimulus from occurring, especially, when these stimuli are integrant parts of the job itself. For instance, teachers are expected to receive and reply to many emails from their students, even if doing so may interrupt other on-going important tasks. It is clear that although organizational and technological solutions should be integrant components of implemented solutions, they may not be effective in buffering against disruptive episodic stressors that cannot be avoided. Also, technological and organizational solutions are general in nature and designed to accommodate a large number of users; and as such, these solutions may not fit different contexts, stressors, or individuals. Providing agency to individuals themselves to combat technostress will help fill the gap where technological and organizational solutions are not effective.

Another solution for preventing the stress response from being initiated is to enhance the resilience of the individual so that the stimulus is not appraised to be a stressor, or when it is evaluated as a stressor, the individual is equipped to address it effectively. Here, we define *resilience* as the predisposition of a user to not have a stress response triggered when exposed to a stimulus that usually causes a stress response, and/or the ability to select and implement effective coping strategies when the stress response is triggered. In the case of unavoidable stressors, building the resilience of the individual to the stressful stimuli may be the pragmatic method for buffering technostress. Hence, strengthening the user's resilience to deal with unexpected techno-stressors when they arise should be part of the arsenal since it is not feasible to prevent all occurrences of episodic stressors. Enhancing resilience provides agency to users since each individual decides which method works best for them, provided that they have the means for implementing their method of choice.

Of note, agency in addressing techno-stress is complicated by the fact that a stress response can be unconscious and triggered through previously learned conditioned responses (Lovallo 2016). Hence, for a method to be effective against techno-stress, it should prevent the stress response from being initiated when the stimulus arises, even when the individual is not aware of the occurrence of the stress response. This is where the knowledge of the biological processes of a stress comes in handy. Indeed, the amygdala is the main brain structure responsible for initiating the physiological stress response through the HPA axis and the SAM system, whether unconscious or conscious. The amygdala is also the main brain structure (among others) that shapes an individual's affect state. Previous studies have shown that the physiological state of the amygdala when a stimulus occurs influences how an individual responds to that stimulus (Wang et al. 2006; Okon-Singer et al. 2015). That is, a negative affect state makes the amygdala more sensitive to stressors, while in contrast, a positive affect state renders it less sensitive and less likely to trigger a distress response. Since the amygdala is the center for affect state, and since inducing a specific affect state in an individual impacts its physiological state, affect regulation methods (e.g. listening to music, practicing mindful meditation) can be used to influence the physiological state of the amygdala, and thus, its propensity for triggering a stress response when an episodic stressor occurs. Hence, affect regulation can be used as a stress alleviation method for technostress Level 1 of Eason's Human-Computer Interaction framework, that is, a stress response involving only the user and the computer. Details on the role of the amygdala in affect and stress response are provided in Section 2.1.

In summary, providing agency to users with the objective of promoting their resilience to episodic stressors can help protect these individuals against techno-stressors that can cannot be eliminated through the design of user-friendly ICT applications/devices or through the adoption of organization-wide policies. Demonstrating that affect can be used to alleviate the effect of episodic stressors has the potential to serve as a framework for ICT users to develop their own approach for preventing techno-distress.

1.4 Overview of Solutions Proposed for Alleviating Techno-distress

Given the health consequences of stress in general, and the negative impact of technostress on task performance and job satisfaction, research has examined solutions for alleviating techno-distress. The proposed solutions can be described through the lens of the theory of preventive stress management (TPSM; Quick et al. 1997) that has guided the understanding and practices of alleviating stress in organizational work environments (Hargrove et al. 2011). As per this model, stress can be dealt with through primary prevention interventions, aimed to reduce the impact of stressors at the source, or through secondary prevention that moderate individual responses to stress, or finally through tertiary prevention that is geared towards helping individuals deal with the outcomes of stress. See Figure 3. Nelson and Ketke (1990) proposed a framework similar to TPSM for addressing stress caused by the adoption of technology in organizations. As in TPSM, Nelson and Ketke's framework describes three types of interventions: primary intervention, direct at the stressors; secondary intervention, aimed at minimizing the stress response; and tertiary intervention, aimed at treating the stress symptoms.

Solutions proposed for tackling techno-distress can be categorized according to the three prevention methods of the TPSM. See Table 1. With the exception of a few (e.g. relaxation exercise by Arnetz 1996; feature control by Galluch et al. 2015), most of these solutions have not been tested through experimental studies. The available evidence of their potential impact on techno-distress rests mainly on surveys of computer users. For instance, mindfulness as an alleviator of techno-distress was inferred from cross-sectional surveys of ICT users (Ioannou & Papazafeiropoulou 2017; Maier et al. 2017). Other proposed solutions are still at the conceptual phase with no evidence or data to support their impact on techno-distress. For instance, Brivio and colleagues (2018) propose that technostress can be mitigated through the use of positive technology, which describes the design and use of technology to enhance users' well-being (Riva et al. 2012). The suggestion by Brivio and coauthors (2018) is based on positive psychology, the notion that positive psychological outcomes can be leveraged to combat negative outcomes. Positive technology itself is ascribed three dimensions: hedonic (pleasure in using the technology); eudemonic (engaging); and social/interpersonal (creating feeling of connectedness with others) (Riva et al. 2012).

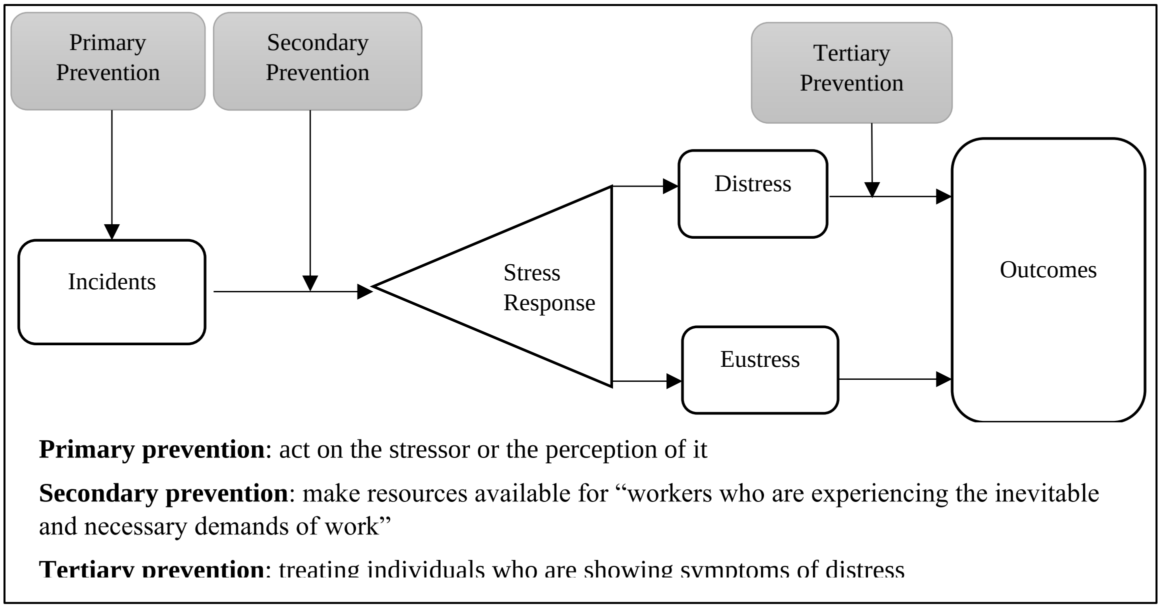


Figure 3: The Theory of Preventive Stress Management (adapted from Hargrove et al. 2011)

Table 1: Methods for alleviating techno-distress

Level	Primary prevention solution	Secondary prevention solution	Tertiary prevention solution
Organization	-Holding IT training sessions -Making user manuals and training materials available -Taking into account employees IT skills when assigning them job-related tasks -Consulting with organization members in the adoption of new technology (Ragu-Nathan et al. 2008)	-Setting a technical support division (Ragu-Nathan et al. 2008) -Adoption of daily breaks schedule (Boucsein & Thum 1997)	Referring individuals with clinical or serious symptoms of stress to counseling or other appropriate services
User	Enhancing computer self-efficacy (preventing technical issues arising from the lack of knowledge of a computer application)	- Enhancing of computer self-efficacy (solving technical issues when they arise)	

Level	Primary prevention solution	Secondary prevention solution	Tertiary prevention solution
	(Salanova et al. 2013; Tarafdar et al. 2015)	(Salanova et al. 2013; Tarafdar et al. 2015) -Education on stress (Arnetz 1997) -Relaxation exercise (Arnetz 1996) -Mindfulness (Ioannou & Papazafeiropoulou 2017 ; Maier et al. 2017)	-
Computer	Shorter response time	-Controllability over stressor (Galluch et al. 2015) -Affective computing -Positive technology (Brivio et al. 2018)	-

1.5 Transactional Model of Stress and Coping: Relational Meaning and Coping Strategies

The Transactional Model of Stress and Coping (TMSC) proposed by Folkman and Lazarus (1984) is the most frequently used theoretical framework in IS for investigating technostress (Ragu-Nathan et al. 2008; Tarafdar et al. 2019). TMSC is a Stimulus-Organism-Response (SOR) model, which posits that the stimulus is first evaluated internally by the organism before generating a response (Lazarus 1999). The SOR model differs from the classical Stimulus-Response (SR) model which neglects or dismisses the internal evaluation of the stimulus. The limitation of an SR model is that it fails to explain why two identical individuals exposed to the same stimulus react differently to the stimulus; or why the same individual will react differently to the same stimulus in two different timepoints. A SOR model attributes these differences in responses to a stimulus to the internal evaluation of the stimulus. If the same stimulus is assessed differently by two individuals, their responses to it will be different. Likewise, if a person evaluates the same stimulus differently at different points in time, their response to the stimulus will be different across these timepoints.

As a SOR model, TMSC emphasizes the internal appraisal of the stimulus by the individual. The person evaluates what the stimulus means to them, and how it relates to other factors that are being considered (e.g. completing a task or taking a break). The meaning ascribed by the individual to the stimulus with regard to its relationship with other co-existing factors is termed “relational meaning”.

Below, we first elaborate the concept of relational meaning, and then discuss how the appraisal of the stimulus shapes the individual’s response to it.

1.5.1 The Role of Relational Meaning in the Transactional Model of Stress and Coping

TMSC describes the psychological process leading to a stress response as a relationship assumed by an individual to be existing between two variables. Relational meaning, that is, how a person construes the relationship that exists between two variables, is crucial in determining how they react when they encounter both variables in their environment. For instance, receiving a large volume of emails (variable 1) while performing a task (variable 2) can be interpreted as a hindrance to task performance (negative) or as an enhancement of task quality (positive), especially if the incoming emails are task-related Relational meaning is not the product of interaction between the two variables, but rather the interpretation given to the combination of both variables by the individual. Also, relational meaning, as the product of an individual's cognitive processes, can be influenced by the person's affect state. How affect impacts relational meaning is through its influence on the appraisal process. Research has observed that the individual's affect state when a stimulus occurs can impact how the stimulus is appraised (Lazarus & Folkman 1984). Cognition and affect state are closely related, and there is a dynamic interplay between their processes, that is, how we feel (affect state) influences how we think (cognition) (Okon-Singer et al. 2015). This affect-cognition interaction will be detailed in a later section below. Based, on the interconnection between cognition and affect, we posit that a person's affect state is an additional factor that can impact the shaping of a relational meaning See Figure 4.

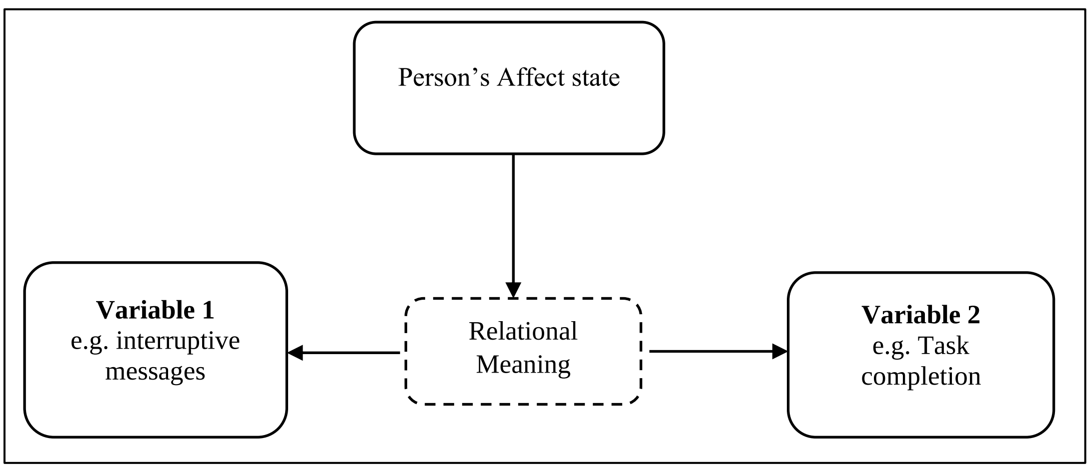


Figure 4: Concept of relational meaning in the transactional model of stress and coping

1.5.2 The Key Role of Appraisal in the Stress Process

The relational meaning of a stimulus with co-existing factors is evaluated during the appraisal of the stimulus by the individual. As a reminder, per TMSC, stress is a transactional process whereby the nature and the intensity of individuals' responses differ according to these individuals' characteristics and their evaluation of the stimulus. Indeed, the appraisal of the stressful stimulus by the individual is a key step among the stages leading to the stress response. Two types of appraisal are usually involved. The first appraisal is termed *primary appraisal* and during this stage the individual assesses whether the stimulus threatens their goals, commitments, or beliefs. This is the stage during which the relational meaning between the stimulus and the person's objectives is gauged. If the person determines that the stimulus does not hinder their objectives, the process is terminated, and no further action is taken. However, if they appraise the stimulus to be an obstacle to achieving their goals, a stress response is initiated. The second type of appraisal, called *secondary appraisal*, involves the evaluation by the individual of the available options for addressing the stressful stimulus. Hence, during the secondary appraisal, the individual assesses how to cope with the stress they are experiencing. See Figure 5.

The stress response is usually termed distress when it negatively impacts the individual's wellbeing and performance. This is the case when the stress experienced by the person is consecutive to a traumatic event; the loss of a loved one or a valuable property; or when the individual is dreadfully expecting a negative outcome to happen (Lazarus 1999). However, stress can also enhance an employee's task performance by providing them with the optimal alertness or sense of urgency required for the task (Heikkilä et al. 2015). Such form of stress is termed eustress since it positively impacts the individual's performance. A stressful stimulus can lead to eustress rather than distress only when the individual appraises the stressor to be a surmountable challenge rather that a threat to their wellbeing or a burden preventing them to achieve their goals (Lazarus 1999). Self-efficacy and confidence in one's ability to perform the specific task is paramount to a stressor leading to eustress rather than distress.

In summary, under the perspective of TMSC, exposure to a stimulus elicits individuals' cognitive functions to evaluate the stimulus, and if the stimulus is found to be a stressor, to examine the options available for addressing or adapting to it. Hence, there is a deep involvement of the individual's cognitive resources in shaping their response to a stimulus. Given the dynamic interactions that exist between cognitive and affective processes, it stands to reason that the person's affect state also contributes to shaping their response to a stimulus.

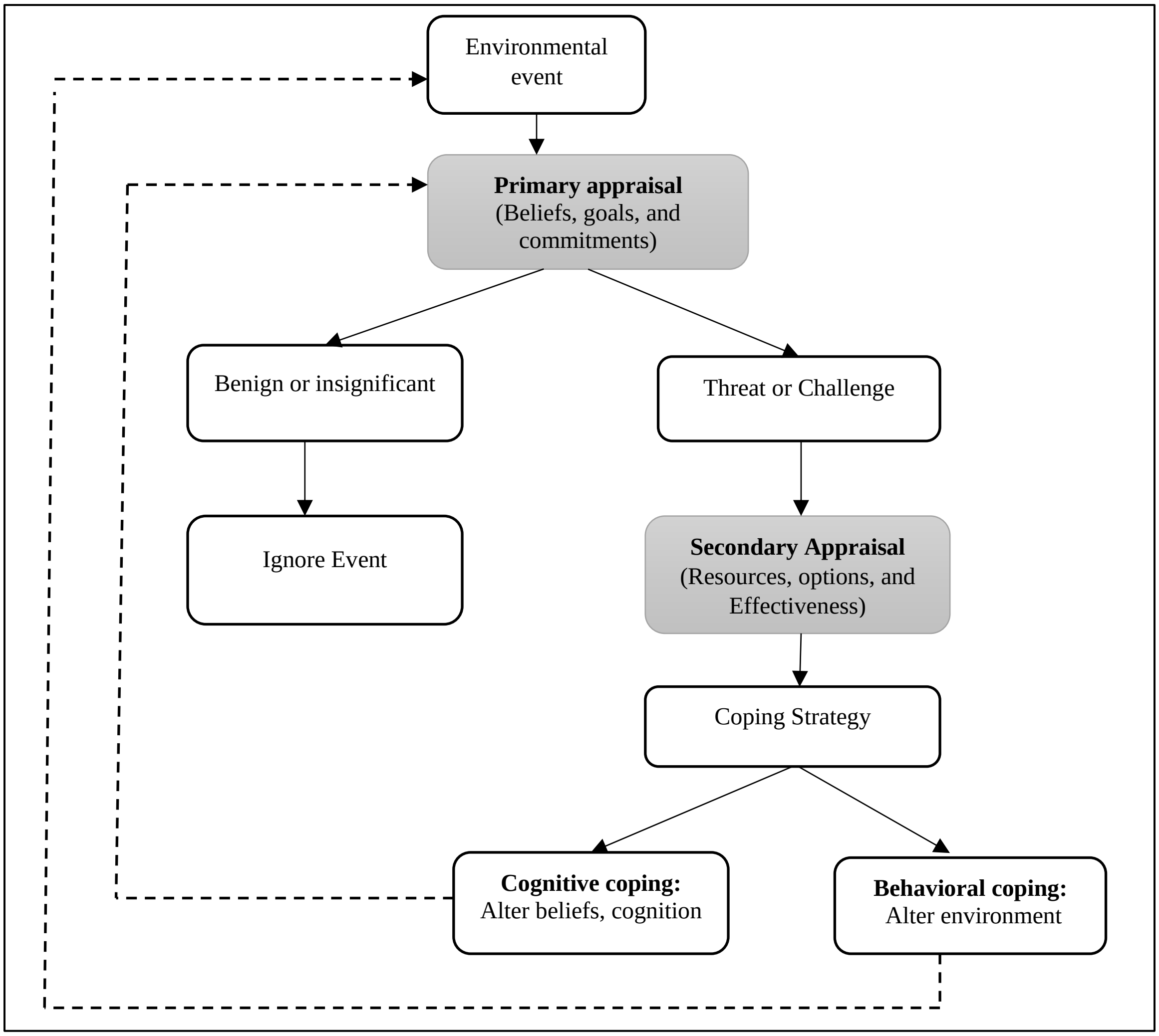


Figure 5: Transactional Model of Stress and Coping (adapted from Lovallo 2016)

2. RESEARCH MODEL AND HYPOTHESES

The research framework we propose in the current research integrates the underlying biological processes of a stress response. As described above, a stimulus has to be appraised first by the individual before any stress response could be initiated through the activation of the HPA axis or the SAM system. The appraisal of a stimulus involves brain structures, namely among others, the amygdala which is responsible for regulating a person's affect, and the prefrontal cortex, which is mainly involved in cognitive processes (e.g. working memory) (Lovallo 2016). We present the findings of the literature on how the amygdala impacts the individual's response to a stimulus by influencing the primary appraisal of the stimulus. We then discuss how a person's affect state impacts their cognitive processes, and consequently, their secondary appraisal of the stimulus identified as a stressor and the selection of coping strategies to address the stressor. Finally, we present our research framework that incorporates both the biological and psychological mechanisms involved in a stress response and defines affect as a key construct that shapes the individual's response to a stimulus.

2.1 Key Role of Affect State and the Amygdala in the Primary Appraisal Process

The primary appraisal of a stimulus occurs at both the pre-frontal cortex and the amygdala, with a dynamic interplay between the two cerebral structures. Studies have found that the amygdala is largely involved in shaping an individual's affect (Phan et al. 2002; Murphy et al. 2003; Barrett et al. 2007; Lanteaume et al. 2007). Furthermore, the amygdala is deeply involved in the formation of emotional memory, while the hippocampus is the main center for declarative memory (Lovallo 2016). Information about the stimulus is compared to previously stored memory. If the occurring stimulus was previously stored in memory as a distressful event, it is likely to cause the amygdala to trigger a distress response through its connection with the hypothalamus-Pituitary-Adrenal gland (HPA) axis. Studies have found the amygdala to be sensitive to the intensity (Bonnet et al. 2015) and the valence (Anders et al. 2008; Jin et al. 2015) of the stimulus. Intensity and valence are not coded separately but in combination to indicate the overall qualities of the stimulus (Winston 2005).

The question arises on how the existing state of the amygdala affects the appraisal process of the stimulus. Does the amygdala existing state (negative or positive affect) become the default response type to an occurring event? For instance, is an amygdala in a state of negative affect state more likely to appraise a stimulus as a negative stressor than an amygdala in a positive or a neutral affect state?

There is ample evidence that the physiological state of the amygdala when the appraisal of the stimulus occurs can impact the result of the appraisal itself. The sensitivity of the amygdala to external stimuli is determined by individual factors, including genetics, biological parameters, and psychological traits. Research has found that the amygdala in individuals with mood disorders (e.g., depression) is particularly sensitive to and shows a sustained activation from negatively valenced stimuli (Siegle et al. 2002).

In an animal model, Rosenkranz and colleagues (2010) observed that chronic stress causes the amygdala to become hypersensitive to external stimuli by decreasing the regulatory effect of calcium activated potassium channels in neurons of the lateral amygdala. This means, for instance, that organizational employees who are in a state of chronic stress are likely to experience more severely an episodic work-related stressor compared to their counterparts who are not chronically stressed. In an experimental study, van der Zwaag and coauthors (2011) found that individuals who listened to high energy negative music showed higher anger induction during simulated driving compared to those listening to positive music. The sensitivity of the amygdala to negative stimuli was found to be enhanced after viewing a sad movie, but not by the viewing of a happy movie (Wang et al. 2006). All these findings demonstrate that the existing affect state of the individual when a stimulus arises influences how individuals appraise these events.

How a positive affect sate can impact cognitive processes and the appraisal of stimuli has been examined by research as well. On the physiological standpoint, there is evidence of the release of endogenous opioids during a positive affect state (Koepp et al. 2009). These opioids can relieve the individual from the bleak feeling of negatively charged memories and enhance attention (van Steenbergen et al. 2019).

Thus, a negative affect state causes the amygdala to be very sensitive to potential negative stimuli, and the response resulting from being exposed to these stimuli is heightened and sustained. In contrast, a positive affect state, by causing the amygdala to be less sensitive to negative stimuli, can be a buffer against stress. Hence, we posit that the user’s affect state is a moderator of the relationship between an IT stimulus and its first appraisal.

2.2 Affect State and Secondary Appraisal: Affect State Impacts Cognitive Scope

The secondary appraisal in TMSC describes the process of weighing the coping resources available for dealing with the event appraised to be a stressor. Folkman and Lazarus (1984) define coping as the cognitive and behavioral methods used by the individual to address the stressor. Thus, selecting a coping strategy involves mobilizing one’s cognitive resources, with the concurrent cognitive state of the individual being important for adopting an effective strategy.

Experimental studies have demonstrated that cognitive processes and attentional scope are impacted by the individual’s affect state. That is, a positive affect state expands attention scope and enable working memory to access long term memories more easily. A negative affect state, in the other hand, constricts attention scope and makes access to long term memory more difficult (Friedman & Förster 2010). Authors have suggested that the attention narrowing is an adaptive mechanism that enables an individual in a stressful situation to focus on the stressor and adopt solutions addressing that stressor (Derryberry & Tucker 1994). In contrast, the expansion of attention scope when in a positive affect state leads the individual to explore and engage with their environment (Fredrickson 2001; Fredrickson & Branigan 2005). The broadening of the cognitive scope allows the easy recall of previously known solutions or the emergence of new ideas for tackling the stressor. Also, engagement with the environment can include the search for technical support from a peer when facing with an IT issue, or for social support when experiencing a life challenge. In sum, a positive affect state can lay the ground for the individual to engage in cognitive and behavioral coping strategies that are likely to be effective in addressing the stressor.

A line of research that emerged lately posits that the relationship between affect and attention is not fixed, as reported by the vast body of literature (i.e., positive affect broadens attentional scope while negative affect narrows it), but rather adaptable. Specifically, positive affect fosters and negative affect inhibits whatever attentional mode (broad or focused) an individual happens to be using at a precise moment. If broad attentional scope is the mode being used, positive affect will enhance it while negative affect will inhibit and narrow it. Likewise, if focused attention is the mode in use, positive affect will facilitate it, resulting in an enhanced narrowed attention, while negative affect will inhibit the focused attentional mode, leading to an expanded attentional scope. When neither broad nor focused attentional mode is dominant, affect does not impact attentional scope (Huntsinger 2012, 2013; Huntsinger et al. 2014). According to Huntsinger (2013), the majority of studies have found positive affect to expand attention because broad attentional scope is the default mode, and thus, was probably the most frequent attentional style used by study participants. Since positive affect enhances whatever attentional mode being used by the individual and broad attentional scope being the most frequent style, these studies yielded results of positive affect expanding attentional scope.

Finally, another line of literature contends that, rather than enhancing any specific attentional mode, affect state influences cognitive flexibility, that is, the ability of the individual to shift from one cognitive mode to another as the task requires it. Positive affect enhances cognitive flexibility (Isen 2002; Baumann & Kuhl 2005) and promotes self-control (Isen 2007). Positive affect reinforcing cognitive flexibility is demonstrated by a greater creativity at work (Amabile et al. 2005), an expansion in attentional scope (Rowe et al. 2007), an increase in variety-seeking behavior (Kahn & Isen 1993). The enhanced cognitive flexibility can enhance the adoption of coping strategies that reappraise the stimulus or can facilitate the search of a solution addressing the issue. Cognitive coping strategies found to be effective in reducing the negative impact of a stressor are those that lead the individual to reinterpret the significance of the stressor. These include positive reappraisal, positive refocusing, design of a plan of action, and search for social support. Although cross-sectional studies prevent from establishing a temporal sequence between two variables that are found to be associated, it is worth mentioning a few studies that found a positive association between positive affect on one hand, and problem-focused coping, or positive reappraisal on the other hand, e.g. Dunkley et al. 2003; Ben-Zur 2009; Dunkley et al. 2017.

It is worth mentioning the stream of research which contends that motivational intensity rather than affect state is the factor that impacts attention scope (Gable & Harmon-Jones 2010; Harmon-Jones et al. 2011; Harmon-Jones et al. 2012). For these authors, both positive and negative affect high in motivational intensity narrow the attention scope, while negative and positive affect of low motivational intensity broadens attention. That is, highly motivated individuals, whether in a positive or in a negative affect state, will restrict their attention to attain the goal they set themselves to achieve. In contrast, regardless of the valence of the individual's affect state, attention scope broadens when motivational intensity is low, allowing individuals to better explore their environment. However, other research found that the effect of affect state on cognition persisted after motivational state was held constant, suggesting that affect is an independent factor influencing cognitive processes (Huntsinger et al. 2014). We adopt the viewpoint that affect independently impacts an individual's attention scope and other cognitive outcomes.

In summary, although the specific mechanism or explanation may differ across authors, a large body of the literature has reported evidence of individuals' affect state influencing their cognitive processes, with positive affect broadening the attention scope and facilitating working memory, and negative impairing these processes. Since the search for coping strategies engage individuals' cognitive resources, it is likely that affect state influences also how these individuals select and adopt a coping method when experiencing technostress.

2.3 Research model

In developing our research model, we compile the biological underpinnings and the psychological processes of stress. Although these two research streams have evolved mostly independently, both have recognized the role played by affect in the mechanism of stress (Lovallo 2016). Biological studies have emphasized the important function of the amygdala, which is both the neurological center of an individual's affect state and the structure responsible for triggering the underlying biological processes of the stress response. In psychological studies, especially in transactional models of stress, the role played by affect is its contribution in shaping the relational meaning that exists between two variables.

According to TMSC, the relational meaning that exists between two variables for an individual is critical to how the person responds to changes in their environment (Lazarus & Folkman 1984). If the relation between a change in one's environment (variable 1) and one's commitment (variable 2) is appraised as detrimental, a distress response may ensue. However, relational meaning between any two variables is not static and can change according to an individual's beliefs, attitude, or affect state. Hence, one can alter an existing relational meaning by changing, for instance, the individual's affect state. Altering the relational meaning existing between two variables will lead the individual to respond differently than usual when both variables arise in their environment concomitantly. Altering a relational meaning signifies changing how the individual appraises an event that occurs in their environment.

There is evidence that affect state can impact the individual's attention scope, cognitive flexibility, and appraisal of stimuli that arise from their environment (Isen 2002; Friedman & Förster 2010; Eschleman et al. 2012). Given the crucial role played by affect in the appraisal of a stimulus and the adoption of a specific coping strategy when the stimulus is appraised as a threat, we proposed that generating or enhancing a positive affect state can be a buffer against the negative impact of distressful stimuli that occur during HCI. In our research framework, we posit that affect state impacts the primary appraisal and the secondary appraisal of the technological stimuli, and influences the selection of a coping strategy by the individual to address the stimuli. See Figure 6.

The focus of this proposal is distressful stimulus, thus, for the primary appraisal process, we limited our evaluation to the distress response. Note that situations where the stimulus appraised to be a challenge (eustress) are not addressed in the current study.

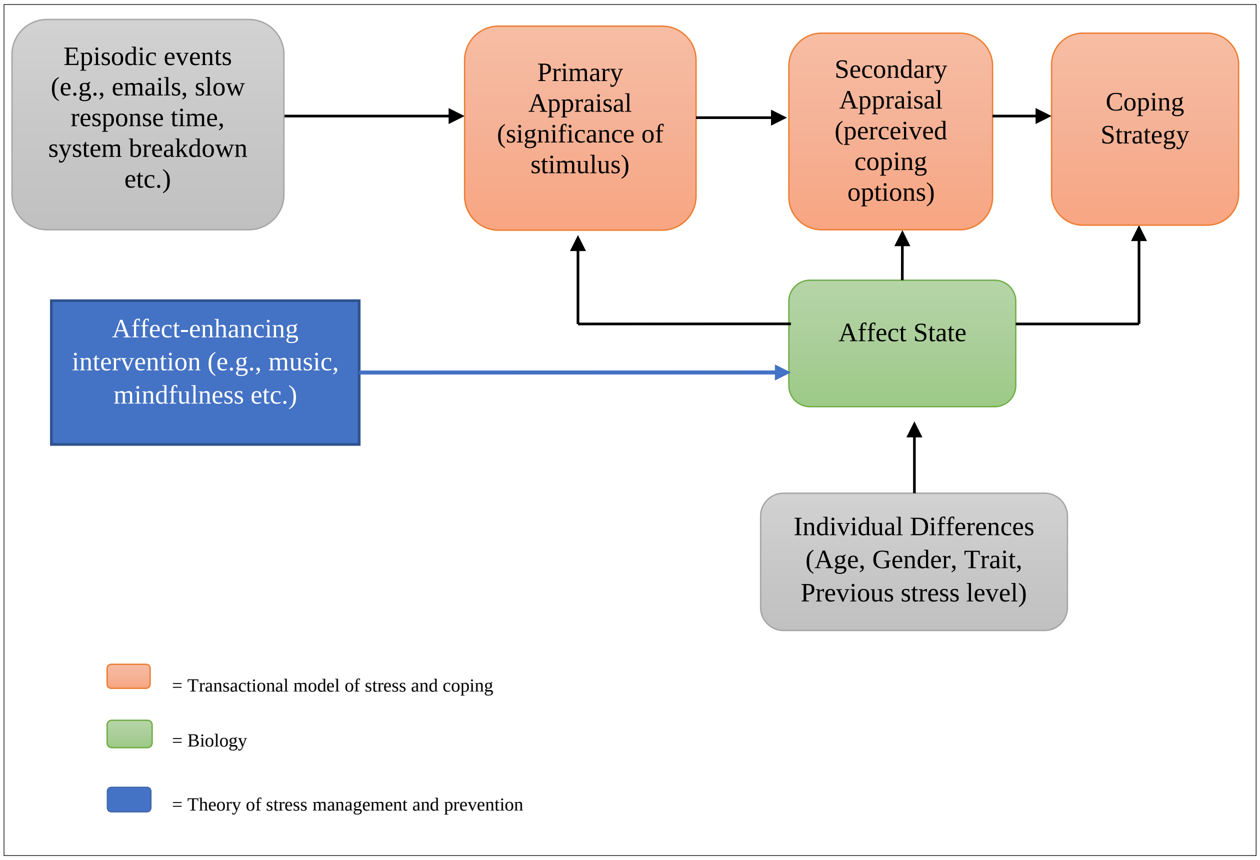


Figure 6: General framework of affect-focused interventions for addressing technostress

2.4 Affect Regulation Methods

Affect is an important component in determining the response of an individual to a stimulus. Hence, regulating affect can help shape how individuals respond to stimuli that may arise during HCI. People regulate their affect state in their daily lives to adapt to the contingencies of their environment. The affect regulation methods used spontaneously by individuals are diverse, including leisure, music, food, substance use (e.g., alcohol), and may be more structured such as daily meditation practice or daily physical exercise. Table 2 presents a few affect regulation methods and their mechanisms.

The neurological mechanisms of affect regulation include a direct effect on the amygdala with inducing a positive-valence activation (e.g., remembering pleasant life events) or decreasing its sensitivity to negative stimuli (e.g., mindfulness meditation). Affect regulation also includes minimizing the sensitivity of the amygdala to negative stimuli by activating the inhibitive role and enhancing the monitoring function played by the cortico-frontal areas (lateral prefrontal cortex, orbitofrontal cortex, and anterior cingulate cortex). Indeed, the activation of these areas have been found to reduce the reactivity of the amygdala (Gyurak et al. 2011). Programs such as affect regulation training (ART) or even anger management programs are aimed to strengthening the regulative role played by these frontal areas on emotion (Berking & Whitley 2014).

Table 2: Examples of affect regulation methods

Affect Regulation Method	Description and Mechanism	Reference
Listening to Music	Enhancing positive affect; Distraction;	van Goethem & Sloboda 2011
Meditation/ Mindfulness	Decrease in amygdala sensitivity to negative stimuli	Desbordes et al. 2012
Affect regulation training (ART)	Enhancing cognitive control of affect	Berking & Whitley 2014

2.4.1 Body posture and physical movements

There is evidence that physical activity reduces the sensitivity of the amygdala to stressful stimuli (Chen et al. 2019). Human body postures and movements, such as walking, enhance an individual's positive affect (Ekkekakis et al. 2000). The physiological mechanisms of body posture influencing affect involves proprioceptive receptors in muscle spindles and tendons, which transmit information on body position to the central nervous system through specific spinal tracts (Izard 1993). The arousal observed during the upright position is due to the activation of the reticular activated system (RAS), a neurological structure involved in wakefulness, REM sleep, muscle tone and locomotion (Garcia-Rill 2009). This activation of the RAS triggers physiological changes readying the organism to sustain the upright position (e.g. increase in blood pressure, heart rate, and muscle tone) and enhances alertness as evidenced by the increase in EEG beta waves activity (Cole 1989). High arousal is a key component of positive affect (Russell 1980).

On the contrary, individuals in a slumped physical posture, reported more negative affect compared to their counterparts who kept an upright posture (Riskind and Gotay 1982; Riskind 1984). More empirical evidence of body posture influencing individuals' affective states include the following: participants who stood upright compared to their counterparts who sat in in a slumped position, indicated higher positive affect in terms of "higher self-esteem, more arousal, better mood, and lower fear" (Nair et al. 2015); an easier recall of positive thoughts when standing upright compared to when in a slumped position (Wilson and Pepper 2004); a greater sense of pride when the news of a success is received in the upright position compared to the sitting position (Stepper and Strack 1993). Furthermore, studies conducted by Labonté-LeMoyne and coauthors (2015; 2016) indicate that individuals using active workstations show more attention and engagement to task compared to those on sitting desks, suggesting that a physically-active interaction with technology can lead to cognitive alertness. Since upright posture creates a positive affect state and greater cognitive alertness, we can expect that individuals completing tasks on a computer using standing and treadmill desks are likely to be less stressed when facing episodic stressors, such as pop-ups, compared to those at sitting desks. The new types of workstations, such as standing desk and treadmill desk, primarily aimed to decrease poor health effects of sitting for long hours, could keep individuals in a positive affect (Sliter and Yuan 2015), and consequently reduce the impact of technostress.

NOTE: The current research proposal initially included investigating whether active workstations, such as standing and treadmill desks, are helpful to alleviating technostress. We planned to conduct a randomized controlled experimental study in which participants would use active workstations in conditions that can test our hypotheses. However, the current COVID-19 pandemic precludes the implementation of this experiment, given that the experimental session requires participants come to a laboratory, and the preparation for physiological data collection (electroencephalogram, heart rate, skin conductance) involves close physical interaction with selected participants.

2.5 Research Hypotheses

2.5.1 Affect state moderates the relationship between stimulus and primary appraisal

Under a neurophysiological perspective, the primary appraisal of a stimulus involves both the prefrontal cortex and the amygdala. Although the prefrontal cortex may exert an inhibitory role on the amygdala, the latter has a preponderant role in the stress response and is responsible for initiating the physiological mechanism of stress by activating the HPA axis (Lovallo 2016). The review of the literature has provided some evidence that the amygdala may be more sensitive to stimuli that have the potential to interfere with the individual's objectives and commitments when the person is in a negative affect state compared to a positive affect state (e.g., Sanchez et al. 2015). Under the TMSC perspective, the change in affect state will alter or modulate the relational meaning that exists between the stimulus (technological event) and the goal of completing the task. Consequently, the technological incidents will be appraised differently by individuals according to their concurrent affect state.

> **Hypothesis 1**: The individuals in a positive affect state will perceive the episodic technological stimulus as a smaller constraint compared to individuals in a negative affect state.

2.5.2 Affect state moderates the relationship between distressful stimulus and secondary appraisal

When a stimulus is appraised as distressful by individuals, they evaluate the options available for addressing the stimulus. The process of weighing the alternatives for tackling or adapting to the stimulus is the secondary appraisal of TMSC. How the individuals perceive the stressor to be controllable, if at all, by themselves or by other persons, is crucial to this process (Folkman 1984; Lazarus & Folkman 1984). Perceived control over the stimulus shapes how an individual assesses the available coping resources. During the transactional process, perceived control can have multiple functions, for instance as an antecedent influencing how the stimulus is appraised, or as an outcome of the transactional process itself (Folkman 1984). In this research proposal, we consider perceived control to be a person's antecedent that can be impacted their affect state. The cognitive flexibility provided by a positive affect state (Isen 2007) offers the individual the opportunity to examine a wider pool of solutions for addressing the stressor. The likelihood of an effective solution emerging from the search is thus higher during a positive affect state compared to when in a negative affect state. For instance, we expect individuals in a positive affect state to be more likely to answer "yes" to the question "will I be able to overcome the problem caused by these pop-ups?" compared to individuals in a negative affect state.

> **Hypothesis 2:** The individuals in a positive affect state will perceive the episodic technological stimulus as more controllable compared to individuals in a negative affect state.

2.5.3 Affect state influences the selection of coping strategies by the individual

Coping strategies represent the cognitive and behavioral methods used by an individual to adapt to the stimulus that they have appraised to be a stressor. As specified by the TMSC model, the coping strategy used by the individual to address the stressor is key in determining the magnitude and the duration of the stress response (Lazarus & Folkman, 1984). An appropriate and effective coping method can reduce to a minimum level the impact of the stressor such that during subsequent appraisals of the stressor, the individual will find it to be an insignificant or a surmountable challenge. The literature stipulates that coping strategies that attempt actively to resolve the stressor rather than adopting a passive attitude or blaming oneself are the ones that may be effective. However, coping strategies that do not address the stressor are less likely to reduce the negative impact of the stressor. Since the specific stressor is not being addressed per se, subsequent appraisals are likely to assess it to be an insurmountable challenge that threatens the individual's goal.

The positive psychology literature, defined by Sheldon and King (2001) as the "the scientific study of ordinary human strengths and virtues", has examined how individuals' mental positive disposition can help them cope with daily life stressors (Folkman & Moskowitz 2003). Emotional and cognitive regulation can help individuals deal with stressors and alleviate negative psychological outcomes and long-term ill-effects on health (Seligman & Csikszentmihalyi 2000; Sheldon & King 2001). Wood and coauthors (2007) reported that a gratitude mindset, described as the disposition of being thankful for events experienced in daily life, was positively associated with positive reinterpretation of stressors, but negatively associated with self-blame and behavioral disengagement. In fact, a positive affect state, which is a state of pleasant emotions, can be a buffer and reduce the impact of stress (Folkman 1997; Ong et al. 2006; Folkman & Moskowitz 2000). In contrast, during a state of negative affect, the individual is less likely to adopt an effective coping behavior, leading to a strong distress response. Hence, a negative affect can increase the impact of daily stressors on the health and longevity of individuals (Chiang et al. 2018).

A positive affect can buffer stress by enhancing the propensity of individuals to appraise events positively ("the glass is half-full") and by providing individuals with a mental disposition to solve issues that arise in their activities (Folkman & Moskowitz 2000). Indeed, a positive affect improves cognitive alertness (Ashby et al. 1999), and therefore, facilitates the adoption of a problem-solving coping behavior. These findings corroborate the broaden-and-build theory (Frederickson 1998, 2001) which posits that positive affect enhances individuals' awareness and creativity, broadens their perspective, and lead them to examine a wide range of alternatives when facing or solving an issue.

In contrast, a negative affect state can impair the cognitive resources of the individual (Padmala et al. 2011; Shields et al. 2016). This impact on cognitive resources can lead individuals to fall short of finding an appropriate solution for addressing the stressor or not to adopt a problem-focused strategy. Furthermore, rumination, described as "repetitive thinking about negative information", is more likely to emerge when an individual is in a negative affect state (Whitmer & Gotlib 2013). In such instance, the goal of the individual becomes adopting a strategy that addresses the negative affect (e.g. venting of emotion), rather than reappraising the situation or dealing with the issue. Therefore, we hypothesize that:

Hypothesis 3: The individuals in a positive affect state will adopt different types of coping strategy in a negative affect state.

2.5.4 Coping strategy influences task performance

The objective of the coping strategy is to eliminate or minimize the stress response triggered by the stimulus. Individuals can curtail the stress response by directly addressing the stressor or by adapting to that stressor when its elimination or modification is not feasible. An effective coping strategy will be successful in altering or halting the biological mechanisms that underly the stress response (i.e. activation of HPA axis and the SAM system), but an ineffective coping method will fail to reduce or stop the stress response. Hence, when the coping strategy adopted by individuals is not effective, their stress level will remain high, and the biological effects caused by the release of stress hormones will endure. As described earlier, the key hormone that is responsible for the physiological changes during stress is cortisol.

One target of cortisol is the central nervous system, where hundreds of its receptors are located (mineralocorticoid or Type 1, and glucocorticoid or Type 2 receptors) (Meijer et al. 2019). When cortisol binds to these receptors, it alters the regular functioning of the neural structure where the receptors are located. One effect of cortisol is the alteration of cognitive functions, especially memory processes.

We used Atkinson and Shiffrin (1968) Multi-Store Model of memory to describe the effect of stress on memory processes. The Multi-Store Model describes memory as composed of three main stages: sensory register, through which individuals capture information from their environment through sensory receptors (visual, auditory etc.); working memory, which holds readily available information but lasts less than one minute; and long-term memory which can store information indefinitely. Information captured from the environment requires the individual's attention to reach the working memory stage. The passage of information from working memory to long-term memory is done through encoding. Information that has previously been stored in long-term memory can be retrieved back to working memory when that information is needed or required to perform a task. See Figure 7. Working memory is essential to the performance of tasks because only information available in this repository is active and can be readily used.

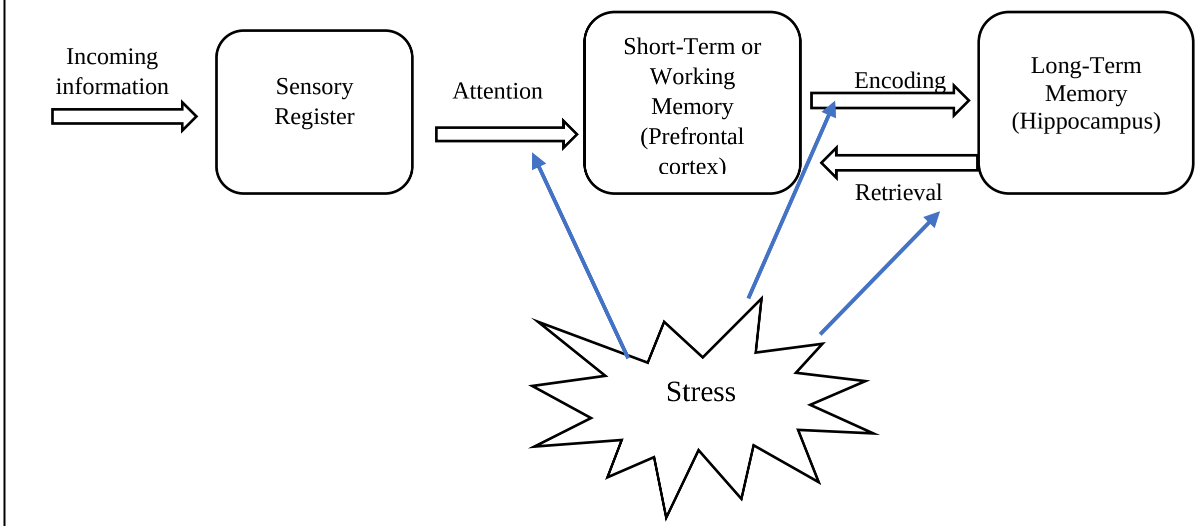
The prefrontal cortex is the main brain structure for working memory (Curtis & D'Esposito 2003; McNab & Klingberg 2008). The hippocampus is an essential structure for the encoding and retrieval of long-term memory, especially declarative memory, that is, memory of facts and events (Tulving & Markowitsch 1998; Eichenbaum 2001; Squire 2004). There are many cortisol receptors located in both the prefrontal cortex and the hippocampus (McEwen et al. 2016; Meijer et al. 2019). The binding of cortisol to its receptors in the prefrontal cortex can interfere with the biological processes that underly working memory formation. Likewise, by binding to receptors located in the hippocampus, cortisol can impair memory retrieval (Kuhlmann et al. 2005). Accessing stored knowledge can then be more challenging for the individual. Hence, stress can alter working memory formation, long-term memory encoding and retrieval.

Although the biological mechanisms of cortisol binding to its receptors located in brain areas is well known, findings about the cognitive effects of a stress response have been mixed, especially for acute stress. There is consensus in the literature that chronic stress has a deleterious on individuals' cognitive performance (Sandström et al. 2005; Marin et al. 2011). However, results on the effects of acute stress on cognitive performance are mixed. Some studies found that acute stress may enhance task performance (e.g., Yuen et al. 2009). In contrast, other researchers have found acute stress to impair working memory and task performance (al'Absi et al. 2002; Oei et al. 2006; Beilock and DeCaro 2007; Schoofs et al. 2008; Luethi et al. 2009; Qin et al. 2009). These diverging results suggest the existence of variables moderating the relationship between acute stress and task performance. Indeed, stress can either impair or facilitate individuals' task performance depending on factors related to the individual, the type of task at hand, and the characteristics of the stress response, including its nature (i.e., either eustress or distress), intensity, and duration (Sandi 2013). Regarding the intensity of the stressor as potential moderator, an inverted U-shape type of relationship between stress and cognition has been suggested, such that cognition processes are mostly impaired at low and high levels of stress, but enhanced at moderate stress levels (Diamond et al. 1992).

In short, an inefficient adaptive response to the stressor will fail to quell or reduce the physiological stress responses initiated by the stressor. On the short term, the unresolved distress response can interfere with the cognitive processes of the individual, leading to a decreased task performance (Luethi et al. 2009; Qin et al. 2009). On the long run, the cumulative effect of multiple stress episodes can lead to a state of chronic stress, impaired cognition, and negative health consequences (McEwen 1998, 2000b). An effective coping strategy is a coping method that minimizes the distress response caused by the stressor. Ineffective coping strategies are not only unable to lessen the distress response but can also amplify it.

In the current research, we focus on acute stress caused by a technological stressor that interrupts the completion of a task. Given that the objective of the individual is the task completion and since the interruptive messages to which the individual is exposed are likely to impede this objective, there is reason to believe that distress rather than eustress will occur. As explained above, this distress response will interfere with the cognitive processes of the individual with the binding of cortisol on its brain receptors. The effectiveness of the coping strategy adopted by the individual will determine the intensity and the duration of the stress response, and consequently, for how long and how much the cognitive processes, especially working memory, are impacted. Since task performance is influenced by working memory, which is impacted by stress response and coping strategy, we hypothesize that:

> **Hypothesis 4:** Participants with different coping strategies will have different task performance.



By impacting attention and memory retrieval, stress can alter the flow of information to working memory, and consequently impact task performance.

Figure 7: Effect of acute distress on working memory formation, long-term memory encoding and retrieval.

2.6 Affect State, Affect Trait, and Personality Trait Dynamics

A psychological trait is defined as a psychological attribute that remains stable and consistent across different contexts and situations over a long period, while a psychological state is a temporary attribute that arises at a specific point in time and lasts over a short period. The current research focuses on the individual's affect state when the stressor occurs.

There are mixed findings on which of trait or state has a direct influence on immediate and contextual individual's behavior. For instance, George (1991) found that it is positive affect state, not affect trait, that was associated with prosocial behaviors at work. That is, individuals are more likely to engage in prosocial behavior when they are in a positive affect state regardless of their psychological trait, and less like to do so when in a negative affect state. In an experimental study, Van't Wout and coauthors (2006) found that participants' affect state impacted their decision making. However, studies have found that affect trait influences how individuals respond when exposed to it (Souza et al. 2007). Also, individuals scoring high on negative affect trait may be slower to recover to baseline after being exposed to a stressful stimulus compared to their counterparts scoring low on negative affect trait scale (Souza et al. 2007).

Studies have found affect trait to be correlated with personality traits (Watson et al. 1992). Specifically, positive affect trait was found to be positively correlated with the extraversion personality trait of the Big Five personality framework, and negative affect trait to be positively correlated with neuroticism (or emotional stability) (Wilson & Gullone 1999; Lucas & Fujita 2000; Charles et al. 2001). Several hypotheses have been proposed to explain the correlation between affect trait and personality traits. Shiota and colleagues (2006) categorizes these suggested explanations in three groups: 1) a given personality trait predisposes to specific affect traits; 2) affect trait forms the core of specific personality traits; and 3) correlated affect traits and personality traits share the same neuroanatomical structures and physiological processes.

Since affect trait and personality trait are correlated, it is not surprising that, as with affect trait, studies have found that personality can influence how individuals respond to a stimulus when exposed to it (Segerstrom 2001; Isaacowitz 2005; Oswald et al. 2006; Oliveira et al. 2009; Childs et al. 2014). The observed differences in responses to stimuli across personality traits can be explained by how individuals with different personality traits perceive or interpret differently, or pay attention differently to the same stimulus. For instance, Isaacowitz (2005) reported that optimistic individuals were less likely to pay attention to negative stimuli compared to their pessimistic counterparts. Schneider (2004) found that neuroticism was positively associated with threat appraisal on a math task, leading to higher stress response and poorer performance on the task compared to their counterparts. Oswald and coauthors (2006) reported a lower reactivity to a psychological stress test in individuals who scored lower on the openness personality trait compared to their counterparts who scored higher on this trait.

Furthermore, personality trait has been found to be associated with affect state, that is, the affect of an individual at a specific time point is influenced by their personality (Lucas & Fujita 2000; Schutte et al. 2003). Hence, the impact of personality trait on immediate behavior or response to a stimulus may be mediated by affect state. The literature findings on the dynamics among personality trait, affect trait, affect state, and immediate behavior are depicted in Figure 8.

Hence, the extant literature suggests that personality trait influences affect state, and both affect state and affect trait, as well personality trait influence individuals’ immediate behavior, including responses to stressors. For this reason, we adjusted for affect trait and personality trait when testing our research hypotheses.

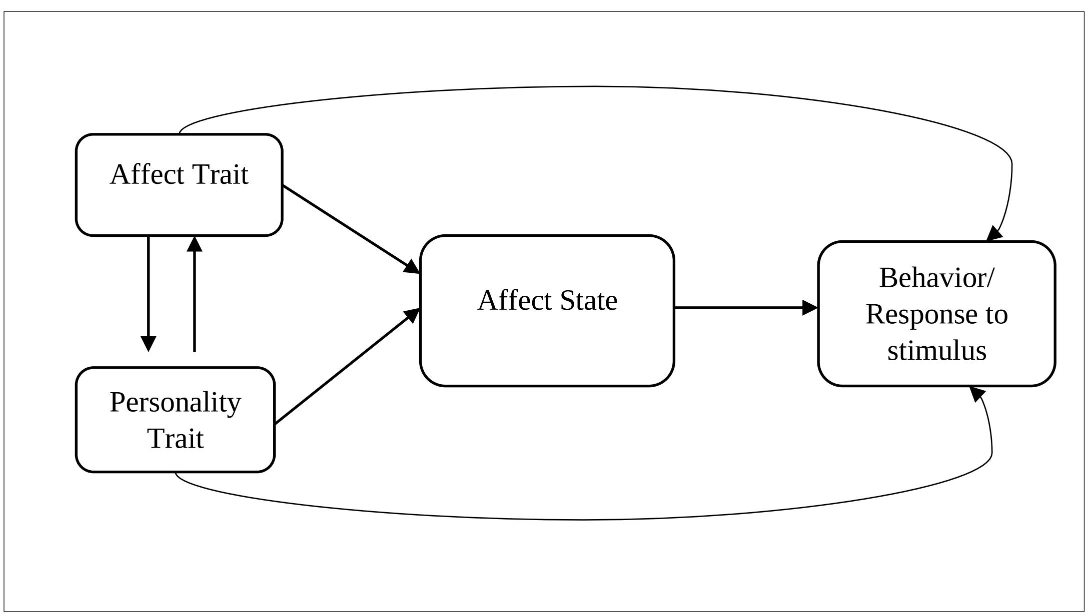


Figure 8: Summary of literature findings on dynamics of personality trait, affect trait, affect state, and immediate behavior.

3. RESEARCH METHOD

3.1 Participants and Inclusion/Exclusion Criteria

A total of 184 participants were recruited from a university in the Midwestern United States. Individuals who were at least 18 years old and familiar with using a computer were eligible for enrollment. Individuals with intellectual disability, and those with uncorrected severe vision deficit precluding the individual to read on a desktop monitor were not eligible for the study. Participants were compensated with a gift card for their time. The study was approved by the Institutional Review Board of the university where the study was conducted. The recruitment email is presented in Appendix 1.

3.2 Experimental Design

The study was a 3 x 1 between-subject experimental design, with the induced affect states (positive affect; negative affect; and neutral affect) as the between-subject factor. Participants were randomized to one of the three between-subject factors. See Figure 9. Each selected individual took part in one experimental session according to their assigned group.

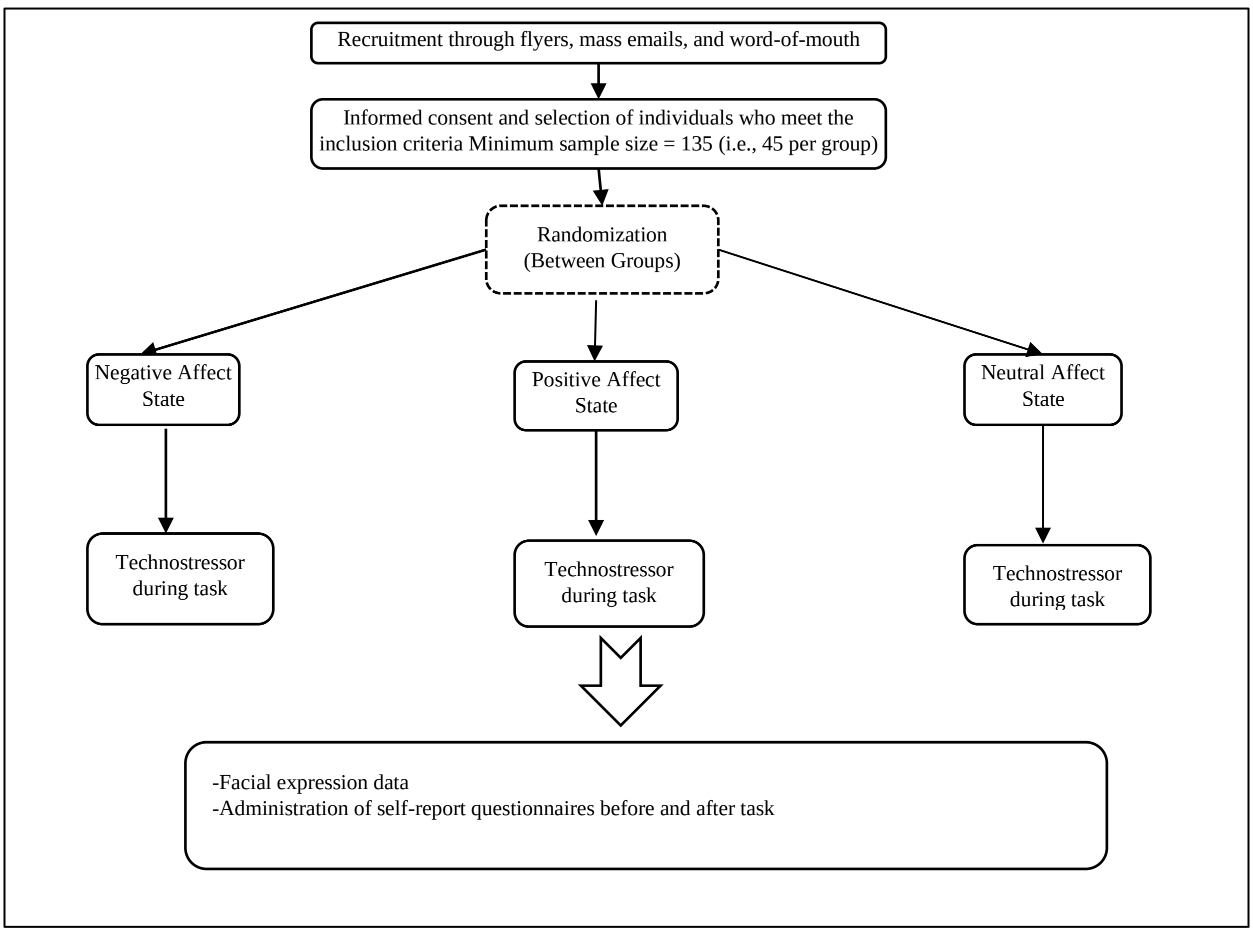


Figure 9: Flowchart of study implementation

3.3 Experimental Conditions: Affect Induction Methods

The study included three experimental groups: 1) induced positive affect; and 2) induced negative affect; and 3) neutral control.

The three affect states were induced with previously tested images selected from the Nencki Affective Picture System (NAPS; Marchewka et al. 2014). The NAPS collection includes 1,356 realistic pictures categorized into five groups (animals, faces, landscapes, objects, and people). These pictures have been validated and demonstrated in previous studies to induce specific affect states in individuals who view them (Marchewka et al. 2014; Riegel et al. 2015; Riegel et al. 2017). The effect of these methods on participants' affect state were evaluated with the Positive Affect – Negative Affect Scale (PANAS; Watson al. 1988). A pilot study was conducted with a few participants to assess and validate the effectiveness of these pictures in inducing the specific affect states in the local socio-cultural context. This pilot guided the selection of pictures from the NAPS collection. During the implementation of the study, we reassessed the effectiveness of the pictures in inducing the intended affect states with the first 30 participants included in the study. This preliminary manipulation check found the selected pictures to be effective in inducing the intended affect states.

3.3.1 Induced positive affect at beginning of task (Group 1)

Participants assigned to this experimental group were asked to look at pictures selected from the NAPS collection (NAPS; Marchewka et al. 2014). The pictures selected for this condition are listed in Table 3.

3.3.2 Induced negative affect at beginning of task (Group 2)

Participants assigned to this group were also asked to look at pictures selected from the NAPS collection (NAPS; Marchewka et al. 2014). The pictures selected for this condition are listed in Table 3.

3.3.3 Neutral control (Group 3)

As with individuals randomized to Positive Affect and the Negative Affect condition, participants assigned to this group were asked to look at pictures selected from the NAPS collection (NAPS; Marchewka et al. 2014). The pictures selected for this condition are listed in Table 3.

Table 3: Selected pictures from the Nencki Affective Picture System (NAPS) for affect state induction

Affect Condition	Positive	Negative	Neutral
Pictures from the Nencki Affective Picture System (NAPS)	**At session start:** faces_116; faces_101; landscapes_147; faces_103;	**At session start**: people_226; people_225; people_211; faces_007;	**At session start**: people_091; objects_247; neutral_618; neutral_132;

Affect Condition	Positive	Negative	Neutral
	faces_110; faces_252; faces_127; faces_107; faces_105; faces_080; landscapes_132; faces_236; faces_235; faces_350; faces_106; faces_131. **During task**: faces_136; faces_139; faces_001; faces_134; faces_122; faces_109; faces_232; faces_263; faces_081; faces_100; faces_104; people_176.	faces_010; people_238; people_022; faces_009; faces_368; people_128; faces_028; faces_011; faces_366; faces_364; faces_365; faces_031. **During task**: faces_363; faces_145; faces_149; faces_143; people_205; people_208; people_020; faces_367; faces_159; faces_371; people_216; blood_022.	objects_306; objects_311; objects_310; objects_312; neutral_715; landscapes_091; neutral_121; objects_299; neutral_434; neutral_125; landscapes_020; neutral_100. **During task**: objects_279; neutral_712; landscapes_067; landscapes_076; neutral_706; neutral_617; objects_314; landscapes_015; neutral_369; objects_307; neutral_015; neutral_104.

3.4 Experimental Task

The experimental tasks were developed based on prior research on cognition and brain executive function. Brain executive functions are those involved in goal planning, deliberation, and decision making. The scientific literature has described these executive brain functions as comprising three dimensions: working memory, set shifting (or cognitive flexibility), and inhibition (Miyake et al. 2000; Diamond 2013). Experimental tasks were selected to match two brain executive functions mainly involved in task performance, working memory and cognitive flexibility. These tasks consisted of scenarios describing practical issues for which the participant was asked to provide the most salient decision. The experimental task is presented in Appendix 2.

3.5 Stressors – Stress Inducing Stimuli

This experimental study is to investigate plausible preventive methods for technostress that emerges from the direct interaction of the user with the computer. Among the events identified as creating technostress, interruptions through pop-ups are considered serious (Tams et al. 2014, Galluch et al. 2015). This stressor was used in the experiment, because it is contemporary, ubiquitous, and of a frequent occurrence in daily interactions with technology. The interruptions through pop-up messages were sent every 30 seconds. The interval of stressors of 30 seconds is long enough to avoid an overlap of stress responses on the physiological signals (Breska et al. 2011). The pop-up message used in the study is presented in Figure 10.

Figure 10: Pop-up message used for triggering technostress response

3.6 Outcome Measures

3.6.1 Self-Report Questionnaires and Task Scores

The reliability of each of the self-report questionnaires (Perceived Stress Scale; Emotional Stability subscale of the International Personality Item Pool; Locus Control scale; Multitasking subscale of the Digital Natives Assessment Scale; Threat and Controllable-by-Self subscales of the Stress Appraisal Measure; identified Adaptive Coping, Maladaptive Coping, and Support Seeking subscales of the BRIEF COPE questionnaire; Positive Affect and Negative Affect subscales of PANAS; Attention-to-Task questionnaire) was measured with the coefficient omega (ω) which has been shown to be a more accurate measure of internal consistency than Cronbach's alpha (Dunn et al. 2014). The 95% confidence intervals of the omega statistics were calculated with 10,000 bootstrap replications. The reliability of the scales used in the study are presented in Table 4.

Table 4: Reliability of the scales used in the study

Scale	Reliability omega (95% CI)
Perceived Stress Scale	0.45 (0.30; 0.58)
IPIP Emotional Stability	0.81 (0.77; 0.84)
Locus Control	0.70 (0.61; 0.75)
DNAS Multitasking	0.77 (0.71; 0.81)
SAM Threat	0.72 (0.64; 0.79)
SAM Controllable-by-Self	0.80 (0.73; 0.84)

BRIEF COPE - Adaptive Coping	0.71 (0.62; 0.77)
BRIEF COPE - Maladaptive Coping	0.65 (0.48; 0.76)
BRIEF COPE - Support Seeking	0.87 (0.79; 0.93)
PANAS Positive Affect subscale	0.86 (0.80; 0.90)
PANAS Negative Affect subscale	0.91 (0.87; 0.93)
Attention-to-Task	0.65 (0.56; 0.72)

Affect State

Affect was gauged with the Positive Affect – Negative Affect Scale (PANAS; Watson al. 1988). The Negative Affect subscale was used to measure negatively-valenced affect state and the Positive Affect subscale to measure positively-valenced affect state. See Appendix 3.

Response to Techno-stressor

Participants' psychological reactions to the technostress stimuli was assessed with validated self-report questionnaires for stress, affective responses, and cognitive states. Primary and secondary appraisal of the stimulus were assessed with the Stress Appraisal Measure (Peacock & Wong 1990). See Appendix 4. Primary appraisal was measured with the Threat subscale, and secondary appraisal with the Controllable-by-Self subscale.

Coping Strategies

Coping strategies were evaluated with the short version of the COPE questionnaire (Brief COPE; Carver 1997). The Brief COPE questionnaire is presented in Appendix 5.

A confirmatory factor analysis showed a relatively good fit of the collected data to the factor structure of the BRIEF COPE (RMSEA = 0.058; CFI = 0.917; IFI=0.922; NFI=0.818). There were two sets of correlated coping factors. The first set included active coping, planning, and positive reframing. The second set included emotional support, instrumental support, self-blame, and self-distraction. Given the observed correlations among these factors, we conducted a second-order confirmatory factor analysis with the correlated factors and confirmed three second-order coping strategies: adaptive coping (active coping, positive reframing, and planning), maladaptive coping (self-blame and self-distraction), and support seeking (emotional support and instrumental support). The goodness of fit statistics supported this second-order CFA (RMSEA = 0.065; CFI = 0.947; IFI=0.948; NFI=0.888; despite the chi-square goodness of fit test being statistically significant: $\chi^2 = 119.8$; df=68; $p < 0.001$). The coping strategies and their items are listed in Table 5.

Table 5: Description of coping strategies used by participants to deal with pop-up messages

	What were my usual reactions when my computer screen was flooded with pop-up messages while I was performing the task: **Possible Answers:** **1 = I have not been doing this at all** **2 = I have been doing this a little bit** **3 = I have been doing this a medium amount** **4 = I have been doing this a lot**

1) Adaptive Coping	
	Active coping
	I have been concentrating my efforts on doing something about the situation I'm in.
	I have been taking action to try to make the situation better.
	Planning
	I have been trying to come up with a strategy about what to do.
	I have been thinking hard about what steps to take.
	Positive Reframing
	I have been trying to see it in a different light, to make it seem more positive.
	I have been looking for something good in what is happening.
2) Maladaptive Coping	
	Self-blame
	I have been criticizing myself.
	I have been blaming myself for things that happened.
	Self-distraction
	I have been turning to work or other activities to take my mind off things.
	I have been doing something to think about it less, such as going to movies, watching TV, reading, daydreaming, sleeping, or shopping.
3) Support Seeking	
	Use of emotional support
	I have been getting emotional support from others.
	I have been getting comfort and understanding from someone.
	Use of instrumental support
	I have been getting help and advice from other people.
	I have been trying to get advice or help from other people about what to do.

Cognitive Functions

The cognitive process of interest is the individual's attention to the task being performed. Attention to task was assessed with the Attention-to-Task questionnaire (Kanfer & Ackerman 1989). See Appendix 6. Cognitive performance and task performance was assessed with participants' test scores on the experimental task. A confirmatory factor analysis of the Attention-to-Task questionnaire found that three items had a factor loading (absolute value) less that 0.45 ("I focused my total attention to solving as quickly as I could"; "I focused my total attention to responding quickly to what I saw"; "I let my mind wander while doing the task"). These three items were dropped from the scale, and the remaining five items were used to gauge participants' attention to task.

3.6.2 Objective Measures

Facial expression analysis

Affect states can trigger facial expressions through the involuntary contraction of facial muscles. Hence, facial expression analysis can be used to infer an individual's affect state and stress level (Zhang et al. 2019). The software iMotions was used to analyze the facial expressions of the study participants during the experimental session from the videos recorded during the session. iMotions uses the algorithm AFFDEX for facial expression analysis (Stöckli et al. 2018). For each facial expression, the software outputs at each timepoint (millisecond) a score ranging from the 0 to 100 that represents the likelihood of the facial expression being detected from the participant. Hence, the higher the score, the more likely is the participant to have expressed the specific facial expression. We set the threshold for emotion detection to 50, the default of the iMotions software. After applying the threshold value to the scores for each specific facial expression, we obtain a binary variable (present/absent) on whether a given participant had the facial expression at each time point. In this study, the percentages of participants assigned to the Positive Affect condition and with the facial expressions of interest at each time point (millisecond) were compared to the ones of participants assigned to the Negative Affect condition.

3.7 Control Variables

Additional variables which were used as control variables were collected at baseline days before the experimental session. These variables included socio-demographics (age, gender, education level) and participants baseline stress level, which was measured with the Perceived Stress Scale (PSS; Cohen et al. 1994). See Appendix 7 and Appendix 8.

Some researchers have suggested that individuals who were born and grew up in an environment with high computer usage ("digital natives") may be better at multitasking and handle better interruptions during HCI than their counterparts who did not grow up in such environment ("digital immigrants") (Prensky 2001a and 2001b). However, these characterizations of "digital natives" have been disputed with empirical data (Kirschner & De Bruyckere 2017). Nevertheless, in our analyses, we measured the extent to which participants were comfortable with multitasking and interruption using the "Comfortable with Multitasking" subscale of the Digital Natives Assessment Scale (Teo 2013). See Appendix 9.

As discussed in an earlier section, personality trait and affect trait may have an influence on how an individual responds to a stimulus (Segerstrom 2001; Isaacowitz 2005; Oswald et al. 2006; Oliveira et al. 2009). Furthermore, some studies have found that the personality type of an individual influence the extent to which they experience and report a stress response (Srivastava et al. 2015; Riedl 2013). For instance, individuals with agreeable personality are less likely to report stress compared to subjects with a neuroticism personality type (Srivastava et al. 2015). Based on these observations, self-reported levels of stress were adjusted for the respondents' personality trait and for affect trait. The International Personality Item Pool (IPIP; Goldberg 1992) was used to assess respondents' personality types. Since the evidence of the association of personality traits with affect state and/or response to stimuli concerns mostly the extraversion and the neuroticism traits (Lucas & Fujita 2000; Letzring & Adamcik 2015), and since answering all the 50 items of the IPIP may lead to respondents' fatigue, only the Extraversion subscale (10 items) and the Emotional Stability subscale (10 items) of the IPIP were administered. See Appendix 10.

Furthermore, how an individual evaluates their control over an event may be influenced by their locus of control. Hence, participants' internal and external locus of control were measured with the Rotter's scale of locus control (Rotter 1966). See Appendix 11.

3.8 Experimental Procedure

All the experimental sessions were conducted online through the platform Zoom (https://zoom.us/). Participants were given access and remote control to the study computer where they performed the experimental task and filled out the post-task questionnaires. Before each session, an experimenter guided the participants through each step of the study. The procedure of the study for a given participant is described in Figure 11. Participants, according to the group to which they had been randomly assigned, participants looked at the selected pictures for affect induction (T1). After the stage of affect induction, participants completed the experimental task (T2) while being exposed to interruptive pop-up messages. Completion of the experimental task took 20 to 30 minutes. The experimental task is presented in Appendix 2. After completing the task, each participant was administered the post-task questionnaires: the PANAS (Watson et al. 1988) for the affect induction manipulation check; the Stress Appraisal Measure (Peacock & Wong 1990); the Attention to task; the Focused Immersion; and the Coping questionnaires (T3). The sequence of the steps for each experimental session is presented in Figure 12.

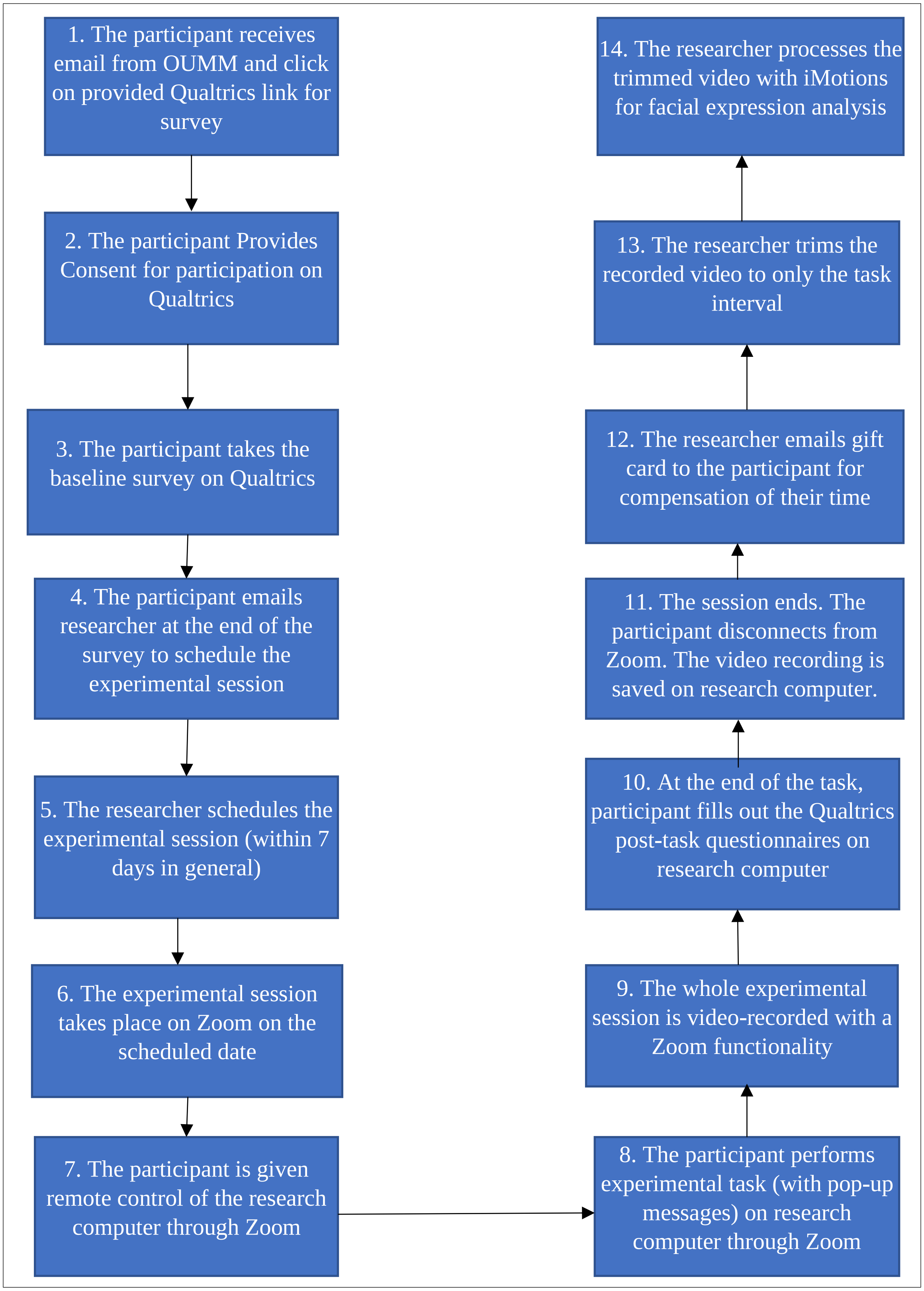


Figure 11: Description of study procedure for an included participant (OUMM = OU Mass Mail)

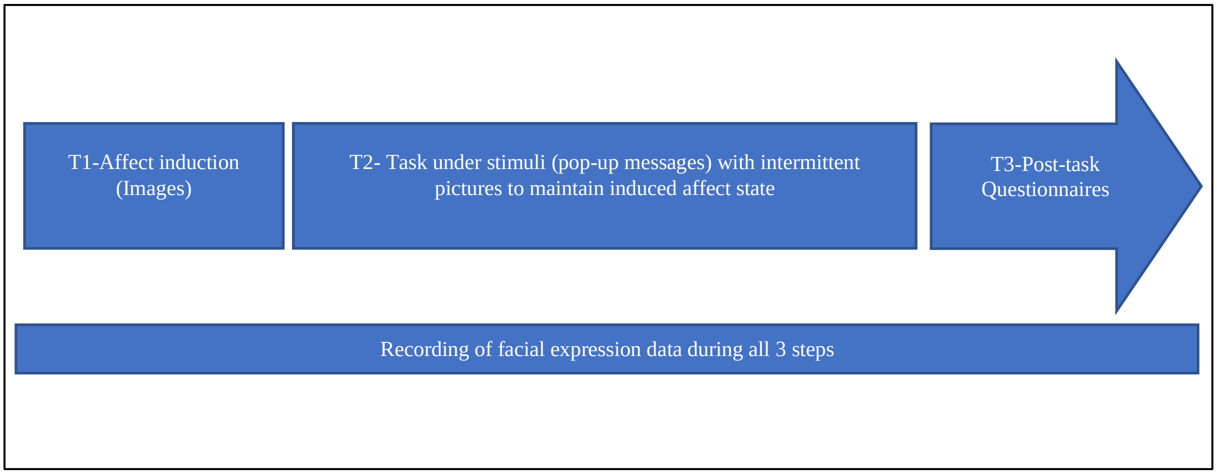


Figure 12: Timeline of an experimental session

3.9 Statistical Analysis and Required Sample Size

A metanalysis found the positive effects of occupational stress management secondary prevention interventions on job stress to be of medium to large sizes (Cohen's d = 0.53, 95% CI 0.36 to 0.69), that is an odds ratio of 2.62 (95% CI 1.92 to 3.50). (Richardson and Rothstein 2008). We expected an effect of similar magnitude for our proposed technostress alleviation methods.

An ANOVA was used for a between-group comparison of the means of the outcomes. For an ANOVA one-way test with four groups, the required minimum sample size for detecting a medium effect size difference (Cohen's f = 0.25) with a type 1 error probability (α) of 0.05 a power of 80% is 135 participants, that is 45 individuals per experimental group.

Multivariable linear models with experimental condition and participants' IPIP emotional stability scores as independent variables were fitted to test the research Hypotheses 1, 2, and 3. For Hypothesis 4 (impact of coping strategy on task performance), we examined the association between the identified coping strategies and task scores with the Spearman correlation statistic. The nonparametric Spearman correlation test, instead of the parametric Pearson correlation test, was used because the task scores and two of the coping strategies (support seeking and maladaptive coping) were not normally distributed. Finally, we used the paired t-test (or its nonparametric equivalent Wilcoxon's signed-rank test when appropriate) to compare the timeseries of the facial expression analysis values between experimental conditions. The software SAS 9.4 was used to fit the Multivariable linear models while SPSS AMOS 28 was used to perform the confirmatory factor analyses for checking the factor structure and items loading of the research questionnaires. The R package MBESS (Kelly 2022) was used to compute the reliability statistic *omega* of the scales.

4. RESULTS

Table 6 presents the characteristics of the study participants at baseline; Table 7 the results of the affect state induction manipulation check; Table 8 the findings for Hypothesis 1, Hypothesis 2, and Hypothesis 3; Table 9 the findings for Hypothesis 4; and Table 10 the summary of the testing of the research hypotheses.

4.1 Baseline Characteristics

A total of 184 individuals participated in the study. Of these 184 participants, 118 (64%) were female, 62 (34%) male, and 4 (2%) of other gender. Participants' age ranged from 18 years to 53 years, with an average of 24 years (standard deviation=7.2) and a median of 21 years.

There was no statistically significant differences in baseline characteristics between the three experimental conditions. Hence, given the randomization and the lack of statistical differences in baseline characteristics among the three groups, we only adjusted for emotional stability when assessing the impact of affect state on the outcomes of interest. Table 6 presents the characteristics of participants at baseline.

Table 6: Baseline characteristics of study participants

Variable / Measure	Positive Condition (n = 64)	Negative Condition (n = 59)	Neutral Condition (n = 61)	Comparing the three conditions (ANOVA One-Way)
Gender	Female = 41 (64%) Male = 23 (36%) Other = 0 (0%)	Female = 42 (71%) Male = 14 (24%) Other = 3 (5%)	Female = 35 (57%) Male = 25 (41%) Other = 1 (2%)	--
Education level [a]	Undergraduate = 38 (59.4%) Graduate = 25 (39.1%) Missing data = 1 (1.6%)	Undergraduate = 44 (74.6%) Graduate = 15 (25.4%) Missing data = 0 (0.0%)	Undergraduate = 40 (65.6%) Graduate = 20 (32.8%) Missing data = 1(1.6)	--
Age (years)	Mean = 25.1 SD = 8.0	Mean = 23.2 SD = 6.0	Mean = 23.4 SD = 7.3	$F(2, 179) = 1.28$; $p = 0.2797$
Emotional Stability	Mean = 30.7 SD = 8.8	Mean = 29.3 SD = 8.8	Mean = 29.8 SD = 7.8	$F(2, 176) = 0.43$; $p = 0.6499$
Locus Control	Mean = 12.7 SD = 3.9	Mean = 13.7 SD = 3.9	Mean = 13.1 SD = 3.9	$F(2, 177) = 1.00$; $p = 0.3690$
DNAS Multitasking Score	Mean = 25.2 SD = 6.0	Mean = 24.7 SD = 6.0	Mean = 26.0 SD = 5.5	$F(2, 177) = 0.67$; $p = 0.5127$

Note: [a] Chi-square test: df = 2; $\chi^2 = 2.81$; $p < 0.2456$ (after removing the two observations with missing data)

4.2 Manipulation check of Affect State Induction

The manipulation check of affect state induction with the pictures was conducted by comparing the average PANAS scores across experimental conditions with one-way ANOVA test. The analysis found that positive affect score was higher in the positive affect condition ($p = 0.0015$) compared to the negative affect condition. Furthermore, negative affect state score was higher in the negative affect condition compared to the positive affect condition ($p < 0.0001$). Both findings confirmed the differences in affect state between the two groups. See Table 7.
However, although positive affect score was higher among participants assigned to the Positive Condition compared to those assigned to the Neutral condition ($p = 0.0166$), there was no statistically significant differences negative affect scores between the two groups ($p = 0.4830$). Since our theoretical framework is concerned with differences in effects between positive and negative affect states, and given the lack of statistically significant difference in negative affect state scores between the Positive and the Neutral conditions, we decided to compare only the Positive Affect and Negative Affect conditions.

Table 7: Manipulation check with PANAS scores

Condition	PANAS Positive Affect Subscale (range: 10 – 50)	PANAS Negative Affect Subscale (range: 10 – 50)
Positive Condition (n=64)	Mean = 23.7 SD = 8.4	Mean = 12.5 SD = 4.2
Negative Condition (n=59)	Mean = 18.8 SD = 6.4	Mean = 24.7 SD = 8.9
Neutral Condition (n=61)	Mean = 19.9 SD = 7.8	Mean = 13.8 SD = 4.2
One-Way ANOVA and pairwise mean differences[a] (95% CI)	$F(2, 181) = 7.0$; $p = 0.0012$ **Positive vs Negative:** 4.8 (1.6; 8.1); $p = 0.0015$ **Positive vs Neutral:** 3.8 (0.6; 7.0); $p = 0.0166$ **Neutral vs Negative:** 1.1 (-2.2; 4.3); $p = 0.7199$	$F(2, 181) = 73.04$; $p < 0.0001$ **Negative vs Positive:** 12.2 (9.6; 14.8); $p < 0.0001$ **Negative vs Neutral:** 10.9 (8.3; 13.6); $p < 0.0001$ **Neutral vs Positive:** 1.3 (-1.3; 3.8); $p = 0.4830$

Note: [a]Adjusted for multiple comparisons using Tukey's method

4.3 Primary Appraisal of Pop-ups

According to TMSC, primary appraisal is the stage where an individual exposed to a stimulus assesses whether the given stimulus is a threat to their objective (distress) or a challenge that can be overcome (eustress). In thus study, we hypothesized that individuals assigned to the Positive Affect condition will perceive the stimulus as less of a threat than individuals assigned to the negative or the neutral conditions:

Hypothesis 1: The individuals in a positive affect state will perceive the episodic technological stimulus as a smaller constraint compared to individuals in a negative affect state.

The statistical analysis found SAM threat score to be significantly lower in the Positive Affect condition compared to the Negative Affect condition, even after adjusting emotional stability scores (p = 0.0193). Hence, our first hypothesis was supported. As presented on Figure 13, a very large increase in the appraisal of the pop-up messages as threat occurred mostly among participants in the Negative Affect condition who had the highest scores on the PANAS negative affect subscale (fourth quartile).

Table 8: Impact of affect state on primary appraisal, secondary appraisal of stimulus, and coping strategy

Condition	SAM Threat	SAM Controllable by Self	Adaptive Coping	Maladaptive Coping	Support Seeking
Positive Condition (n=64)	Mean = 8.2 SD = 2.9	Mean = 15.6 SD = 2.9	Mean = 14.3 SD = 3.9	Mean = 6.0 SD = 2.1	Mean = 4.4 SD = 1.3
Negative Condition (n=59)	Mean = 9.6 SD = 4.2	Mean = 14.6 SD = 3.0	Mean = 12.8 SD = 4.1	Mean = 6.1 SD = 2.4	Mean = 5.0 SD = 2.3
Adjusted Mean Difference Positive versus Negative (adjusting for emotional stability)	-1.6 (-2.8; -0.3); p = 0.0193	1.1 (0.03; 2.1); p = 0.0448	1.5 (0.04; 2.9); p = 0.0446	-0.1 (-1.0; 0.7); p = 0.7521	-0.6 (-1.3; 0.1); p = 0.0912

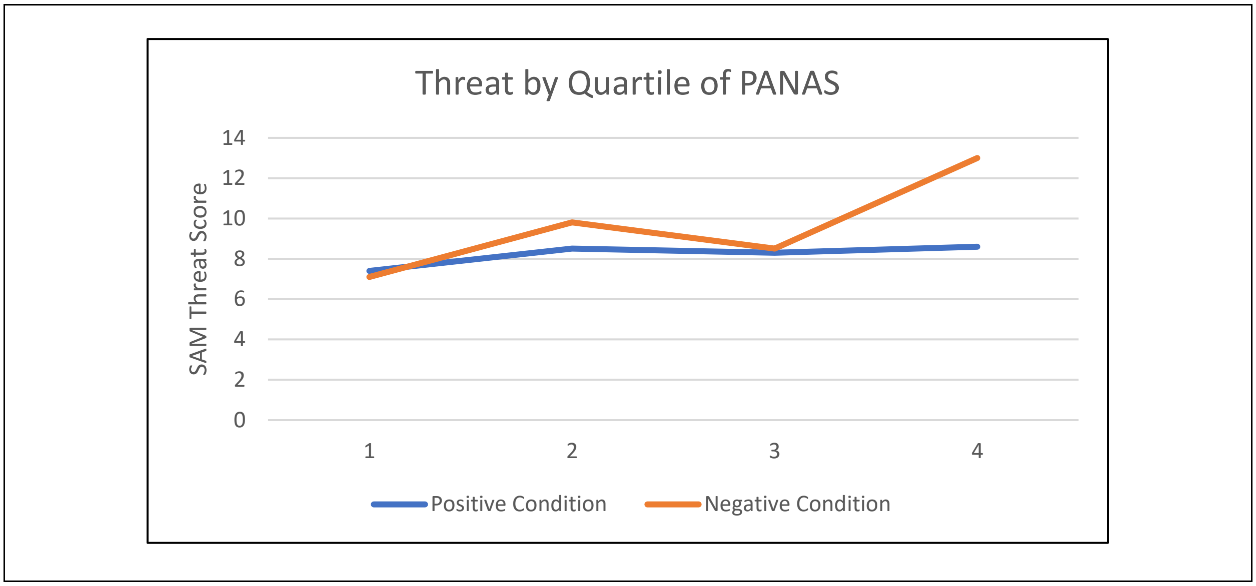


Figure 13: Primary appraisal of stimulus **(**SAM Threat) by quartiles of PANAS positive and negative affect score

4.4 Secondary Appraisal of Pop-ups

The secondary appraisal concerns the cognitive assessment by the individual on whether the stimulus appraised as threat can be remedied or controlled. In this research, we used the SAM subscale of "Controllable by Self" to measure the secondary appraisal of the stimulus. We hypothesized that individuals randomized to the Positive Affect condition will appraised the stimulus as more controllable compared to individuals assigned to the Negative Affect condition:

Hypothesis 2: The individuals in a positive affect state will perceive the episodic technological stimulus as more controllable compared to individuals in a negative affect state.

The analysis found that participants assigned to the Positive Affect condition reported higher scores on the SAM Controllable by Self scale compared to participants assigned to the Negative Condition ($p = 0.0448$). As presented on Figure 14, differences in SAM Controllable by Self scores between Positive Affect and Negative Affect conditions started from the second quartile on the PANAS scores, that is, in the Positive Affect condition, the SAM Controllable by Self scores increased as the PANAS positive affect score increased, while the SAM Controllable by Self scores remained relatively low in the Negative Affect condition.

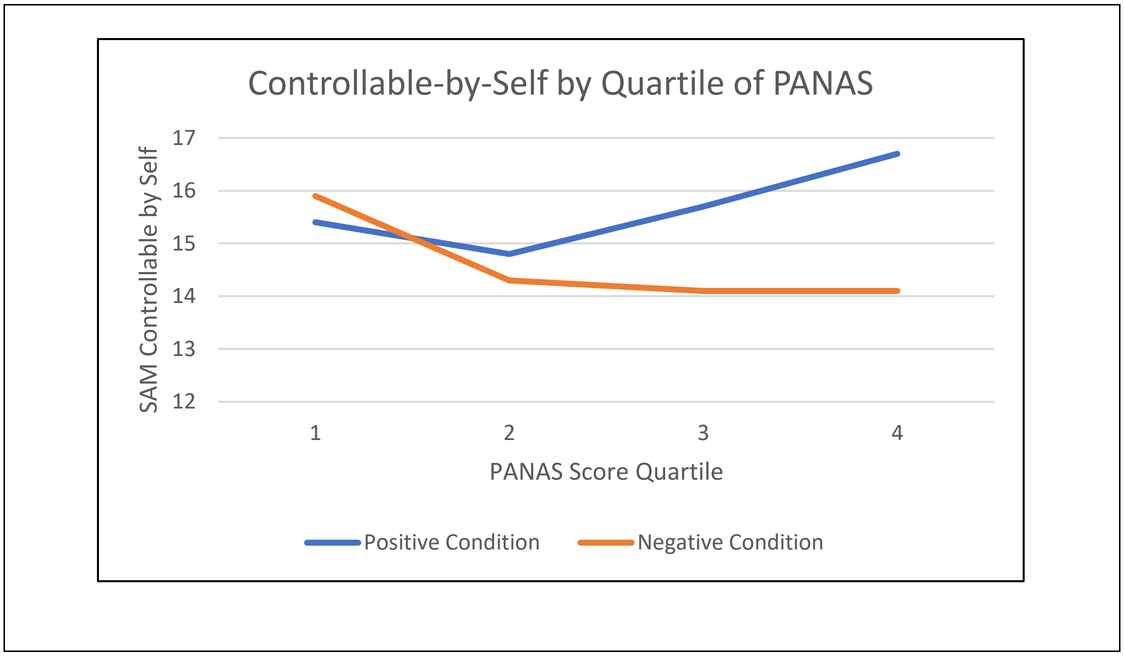


Figure 14: Secondary appraisal of stimulus (SAM Controllable-by-Self) by quartiles of PANAS positive and negative affect score

4.5 Coping Strategies for dealing with pop-ups

Coping strategies describe the cognitive and behavioral adjustments undertaken by an individual to address or adapt to the stimulus perceived to be a threat to their objective. As described in the Methods section, we used the BRIEF COPE questionnaire to gauge participants' coping strategies. The confirmatory factor analysis revealed three second-order coping strategies: adaptive coping, maladaptive coping, and support seeking.

In this study we hypothesized that participants assigned to the Positive Affect condition will adopt different coping strategies compared to individuals assigned to the Negative Affect condition:

Hypothesis 3: The individuals in a positive affect state will adopt different types of coping strategy than those in a negative affect state.

The analysis found that participants who were assigned to the Positive Affect condition had higher scores in Adaptive Coping compared to participants assigned to the Negative Affect condition ($p = 0.0446$). The scores of Maladaptive Coping and Support Seeking were lower among participants in the Positive Affect condition compared to the Negative Affect condition, but the differences were not statistically significant ($p = 0.\ 7521$ and $p = 0.0912$, respectively). See Table 8. Differences in coping strategies between the two conditions appeared mostly when negative affect scores were high among participants assigned to the Negative Affect condition. Specifically, participants with the highest negative affect scores tended to use less adaptive coping, more support seeking, and more maladaptive coping compared to their counterparts. See Figure 11. Also, Support Seeking was positively correlated with Maladaptive Coping (Spearman's correlation r =

0.61; p <0.0001), suggesting that participants who used Support Seeking as coping strategy were more likely to use Maladaptive Coping as well. There was no statistically significant association of Adaptive Coping with Support Seeking ($p = 0.1458$) or Maladaptive Coping ($p = 0.0938$).

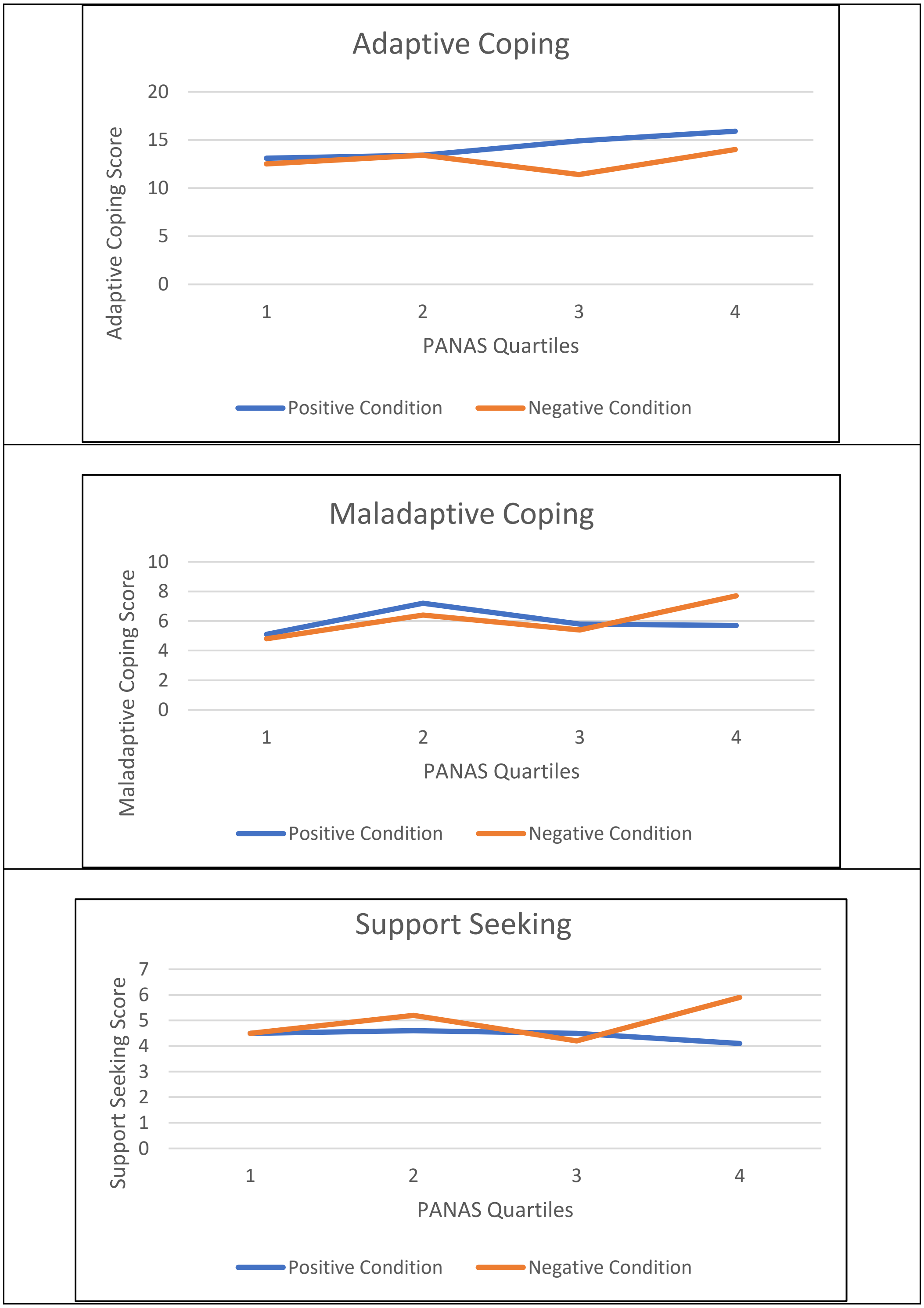


Figure 15: Coping Strategies scores by quartiles of PANAS positive and negative affect scores

4.6 Impact of Pop-ups on Cognitive Processes

In this study we hypothesized that differences in coping strategies adopted by participants to deal with the pop-up messages will lead to differences in task performance:

Hypothesis 4: Participants with different coping strategies will have different task performance.

Among participants assigned to the Positive Affect and Negative Affect conditions, the analysis found a statistically significant negative correlation between test scores and maladaptive coping (Spearman correlation r = -0.24; p = 0.0076), and support seeking (Spearman correlation r = -0.23; p = 0.0110). However, there was no statistically significant association between test scores and adaptive coping (Spearman correlation r = -0.08; p = 0.3786). See Table 9. Hence, adopting support seeking or maladapting coping strategies negatively impacted task performance, lending support to Hypothesis 4.

Additionally, although not part of our research hypotheses, we explored how affect state influenced attention to task. The analysis did not find any statistically significant difference in test scores between the Positive Affect and the Negative Affect conditions (p = 0.2955). A plotting of Attention-to-Task scores by the two experimental conditions quartiles of PANAS positive and negative affect scores found that attention scores decreased as negative affect scores increased among participants assigned to the Negative Affect condition. However, among participants in the Positive Affect condition, average attention score was higher in the fourth quartile of positive affect score compared to lower quartiles. See Figure 16.

Table 9: Spearman correlations between experimental task scores and coping strategies

Coping strategy	Spearman correlation with task scores
Adaptive coping	r = -0.08; p = 0.3786
Maladaptive coping	r = -0.24; p = 0.0076
Support seeking	r = -0.23; p = 0.0110

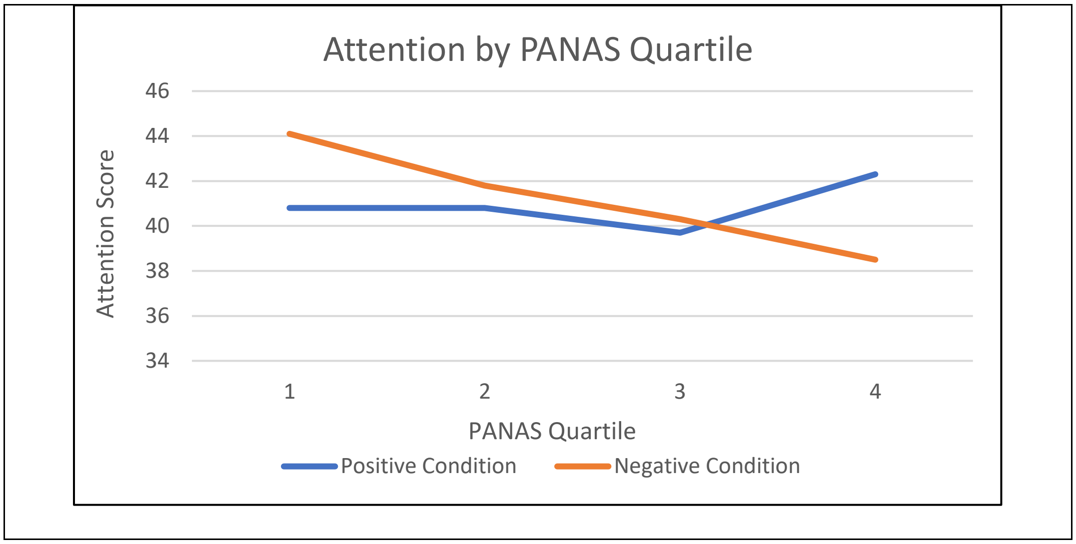


Figure 16: Attention-to-task scores by quartiles of PANAS positive and negative affect scores

4.7 Summary of Hypotheses Tests

Participants assigned to the Positive Affect condition rated the pop-up messages less as threat, found the pop-ups more controllable, and adopted more adaptive coping strategies compared to participants assigned to the Negative Affect condition. Table 10 presents a summary of the results of the hypotheses testing.

Table 10: Summary of research hypotheses and findings

Hypothesis	Results
Hypothesis 1: The individuals in a positive affect state will perceive the episodic technological stimulus as a smaller constraint compared to individuals in a negative affect state.	Supported
Hypothesis 2: The individuals in a positive affect state will perceive the episodic technological stimulus as more controllable compared to individuals in a negative affect state.	Supported
Hypothesis 3: The individuals in a positive affect state will adopt different types of coping strategy in a negative affect state.	Supported
Hypothesis 3: The individuals in a positive affect state will adopt different types of coping strategy in a negative affect state.	Supported

4.8 Corroboration with Physiological Signals

We derived three measures from the analysis of participants' facial expression during the session: rate of participants in a state of fear, number of blinks per minute, and attention rate. The number of blinks per minute has been used by previous literature as a measure of stress (Haak et al. 2009; Giannakakis et al. 2017). The state of fear was selected as a proxy for appraising the pop-up messages as threat, and attention rate as a variable for measuring the impact of these pop-up messages on the participants' cognitive processes.

The rate of participants in a state of fear was higher in the Negative Affect condition compared to the Positive Affect condition (Wilcoxon's signed-rank test: $p < 0.0001$ in the time interval 2 - 15 minutes of the session). See Figure 17. Furthermore, the eye blink rate was higher among participants in the Negative Affect condition compared to their counterparts in the Positive Affect condition (paired t-test: mean difference = 1.13; 95%CI = (1.11; 1.15); $p < 0.0001$ in the time interval 2 - 15 minutes of the session). See Figure 18. Also, attention rate was lower among participants assigned to the Negative Affect condition compared to those in the Positive Affect condition (Wilcoxon's signed-rank test: $p < 0.0001$ in the time interval 2 - 15 minutes of the session). See Figure 19.

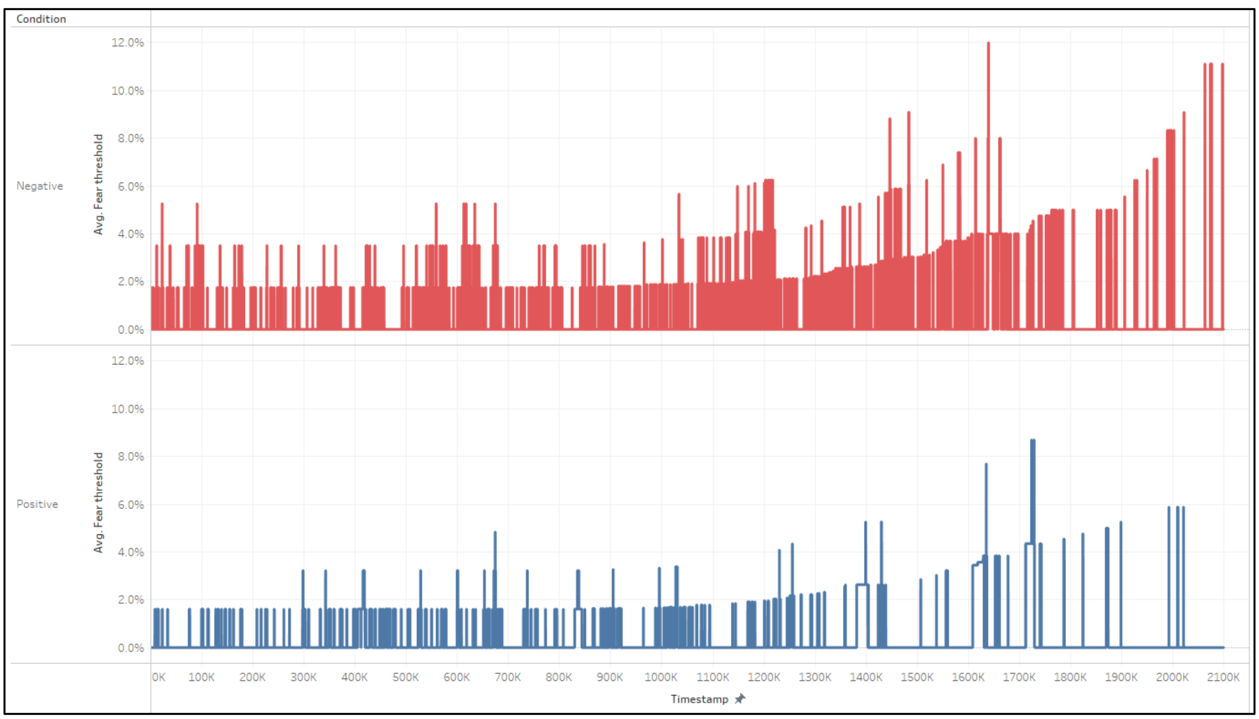


Figure 17: Participants' state of fear during experimental session

Note: Blue: Positive Affect condition; Red: Negative Affect condition. The percentages of participants who had a facial expression of fear were higher in the Negative Affect condition than in those assigned to the Positive Affect condition.

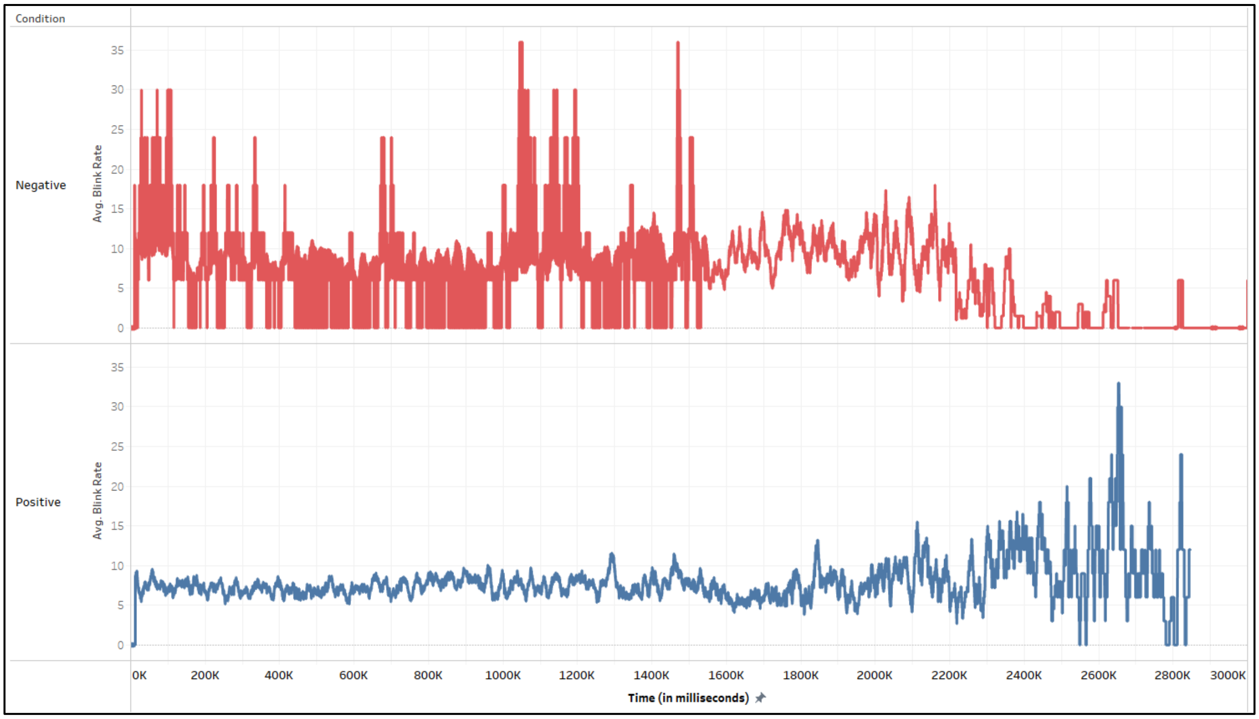


Figure 14: Participants' eye blink rates during experimental session

Note: Blue: Positive Affect condition; Red: Negative Affect condition. Increase in eye blink rates was more frequent in participants assigned to the Negative Affect condition than in those assigned to the Positive Affect condition.

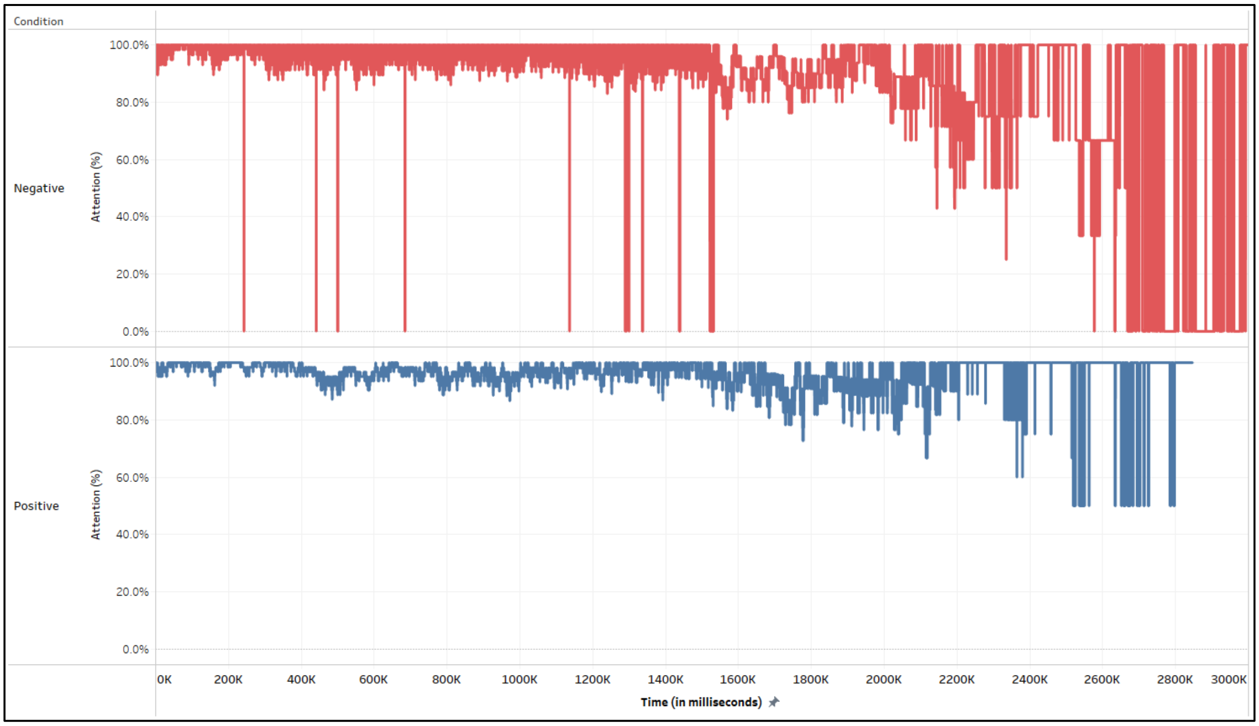


Figure 19: Participants' attention during experimental session

Note: Blue: Positive Affect condition; Red: Negative Affect condition. Drop in attention was more frequent in participants assigned to the Negative Affect condition than in those assigned to the Positive Affect condition.

5. DISCUSSION

The objective of this experimental study was to investigate how individuals' affect state impacts their responses to techno-stressors. Using the transactional model of stress and coping (TMSC; Lazarus and Folkman 1984), the theory of preventive stress management (TPSM) and the biological underpinnings of stress that emphasize the major role played by the cerebral amygdala in shaping affect state and triggering stress responses, we hypothesized that individuals' affect state can be leveraged to influence their responses to techno-stressors. Specifically, we hypothesized that individuals in a positive affect state would be less likely to appraise a stimulus as a threat to performing their task, would be more likely to appraise the stimulus as controllable, and would adopt different coping strategies compared to individuals in a negative affect state. These hypotheses were supported by the experimental data. Indeed, participants who were assigned to the Positive Affect condition appraised the pop-up messages as less of a threat, while assessing these pop-ups as more controllable and adopting more adaptive coping strategies compared to their counterparts assigned to the Negative Affect condition. Furthermore, the study provided evidence to the association between the constructs involved in TMSC. Appraising a stimulus as controllable by oneself (secondary appraisal stage) decreases the likelihood of perceiving this stimulus as a threat (primary appraisal stage) while increasing the likelihood of adopting an adaptive coping strategy (coping stage). These findings corroborate the neurobiological underpinnings of stress and the role that may play affect state in stress responses. A state of positive affect renders the amygdala less sensitive to potentially stressful stimuli, resulting in these stimuli being appraised as less of a threat.

Adaptive coping in this study included active coping (e.g., "I have been taking action to try to make the situation better"), positive reframing (e.g., "I have been trying to see it in a different light, to make it seem more positive"), and planning (e.g., "I have been trying to come up with a strategy about what to do"). Adaptive Coping is in line with Proactive Coping, a coping strategy in which the individual addresses the stressful stimulus through "personal growth and resource accumulation" (Pirkkalainen et al. 2019). The adoption of a proactive coping strategy is a deliberate effort undertaken by individuals to enhance their resilience to the stimulus (Pirkkalainen et al. 2019). Since deliberate actions or behaviors require the involvement of cognitive processes, and since a state of positive affect enhances cognitive processes (Isen 2007), it is understandable that individuals assigned to the Positive Affect condition were more likely to adopt a proactive coping strategy. Hence, our findings provide evidence that positive affect can alleviate technostress by enhancing the propensity of individuals to appraise the technological stressor positively ("the glass is half-full") and by providing them with a mental disposition to solve issues that arise during their task (Folkman & Moskowitz 2000). Furthermore, our results corroborate the broaden-and-build theory (Frederickson 1998, 2001) which proposed that positive affect enhances individuals' awareness and creativity, broadens their perspective, and lead them to examine a variety of alternatives when facing or dealing with an issue.

The analysis of the facial expressions showed a higher eye blink rate in the Negative Affect condition compared to the positive Affect condition, a sign of higher of levels of stress among participants assigned to the Negative Affect condition (Haak et al. 2009; Giannakakis et al. 2017). Furthermore, the finding that attention rate was lower in the Negative Affect condition compared to the positive affect condition corroborates previous literature which reported that stress levels negatively impact cognitive processes (al'Absi et al. 2002; Oei et al. 2006; Beilock and DeCaro 2007; Schoofs et al. 2008).

Below we present the contributions made by this research and its findings to the existing literature and provide suggestions for future research in the area of technostress and potential alleviation methods.

5.1 Theoretical and Practical Contribution

Our proposal offers the opportunity to build a general framework for alleviating technostress. Although there was considerable interest on technostress in the past decade, the construct that most captures stress feelings, and impacts outcomes of stressors, is an individual's affect – yet it is ignored in extant literature (Sarabadani et al. 2018). We address this gap by using a comprehensive study design that captures perceptual and physiological measurements of affect. The contributions of the current proposal are three-fold: theoretical, methodological, and practical.

5.2 Theoretical contribution

Our proposed research provides several theoretical contributions.

First, from an IS standpoint, we propose a framework that incorporates the biological underpinnings of stress in explaining and understanding users' responses to episodic technological incidents during HCI. The large majority of IS studies on technostress have borrowed perspectives from psychology (e.g., TMSC with Raghu-Nathan et al. 2008) or management science (e.g., Environment-Person Fit theory with Ayyagari et al. 2011) without referring to the physiological mechanisms that underly any stress response. The few IS studies that have relied on biological elements (e.g., Tams et al. 2014; Galluch et al. 2015) have studied technostress under a stimulus-response (SR) model viewpoint which ignores the individual's appraisal of the stimulus and the psychological processes of a stress response. For instance, in their experimental study, Tams and coauthors (2014) exposed a group of participants to interruptive messages and compared their levels of salivary alpha-amylase (a stress biomarker) to the ones of participants not exposed to these techno-stressors. Such design does not account for nor explain individual differences in appraising the stimulus. These differences can be explained only through the lens of a stimulus-organism-response (SOR) model, where the individual differences in affect state are considered. Thus, in the current proposal, both psychological and biological processes are articulated to form a SOR model that investigates the response to episodic stressors. Developing from prior work in psychology and IS, we provides a more comprehensive approach to understanding stress responses by accounting for the of individual differences in stimulus appraisal.

Second, the current proposal adds to the IS literature by decomposing and shedding a light on the different stages that take place from the perception of the stimulus by the individual to the triggering of the stress response and the adoption of coping strategies. Information Systems publications that used TMSC as a research framework have been surveys that assessed the relationship between technological stressors and technostress outcomes. Even though TMSC was the theoretical basis in these studies, the research design (cross-sectional survey) did not allow examining the different phases that exist between the exposure to techno-stressors and the emergence of technostress responses. The experimental design in our study gives us the opportunity to examine the different stages of a technostress response, including the primary appraisal, secondary appraisal, and the adoption of a coping strategy. Hence, we provide a deeper insight into the technostress response to episodic incidents compared to previous IS publications.

Third, our proposal enhances TMSC by enriching it with biological evidence and exploring the antecedents of primary and secondary appraisal. One antecedent that may be crucial in determining an individual's response to a stimulus is affect state. Indeed, how affect state may impact stimulus appraisals has not been investigated in previous studies.

Finally, from a multidisciplinary standpoint, although the current research borrows from biological findings on stress response, it also contributes to biology by adding a psychological perspective to the neurophysiological processes.

5.3 Methodological contribution

From a methodological perspective, we use a combination of perceptual and physiological methods to gauge individuals' stress response, demonstrating the value of non-invasive methods such as facial expressions as objective tools for measuring individuals' responses to episodic stressors. Since stress response is often unconscious, the physiological measures can capture stress responses that may not be reported by individuals on the perceptual measures. Also, correlating perceptual with physiological measures that can be recorded with electronic devices can help develop algorithms for detecting a technostress response while it is occurring. These algorithms can be incorporated into wearable technologies that will alert users about the occurrence of a technostress response, especially when it is unconscious, and prompt them to adopt a coping strategy (e.g., taking a break). Technostress-detecting algorithms can also be paired with information communication and technology (ICT) devices so that these devices can modify their functionality or start a specific application (e.g., soothing music) when a technostress response is detected from the user.

5.4 Practical contribution

The current research offers a framework for designing interventions that can alleviate the impact of episodic technological incidents. Since our research provides evidence that supports this framework, interventions that enhance users' positive affect states can be proposed to tackle technostress. Indeed, our investigation of the role played by affect in a stress response caused by episodic techno-stressors, not only provides a better understanding of technostress, but also offers a basis for recommending or designing interventions that can minimize the effects of episodic stressors on ICT users. These interventions centered on users' affect can be the methods of choice in situations where it is not feasible to present the occurrence of techno-stressors either through organizational policies or through better technological design of ICT devices.

In summary, the results obtained from this project not only extend the current knowledge on technostress, but they also have the potential to be implemented in practice in the future to help all people manage technostress and enhance their wellbeing.

5.6 Limitations

The study had some limitations that should be pointed out. First, although we computed beforehand the required sample to detect a medium effect size (Cohen's $f = 0.25$), the effect size was found to be smaller for all the outcomes of interest (e.g., for Support Seeking: Cohen's $f = 0.16$, with the study achieving a statistical power of 47%, instead of the pre-planned minimum of 80%). Hence, there was enough statistical power to detect differences between affect states conditions in some of the outcomes (e.g. Support Seeking). Also, the study included mostly students from a university in the midwestern United States, which may limit the generalizability of the findings. Note, however, that some of the participants were working professionals pursuing a degree. Another limitation is the non-direct observation of the amygdala of participants during the session. With the current technology, such direct observation can be performed only with functional magnetic resonance imagery (fMRI). The usual body position adopted for performing fMRI examination (individual usually lying down in supine position) may not be practical for conducting experiments that plan to replicate office work environments. Even though we did not collect fMRI data in our study, our findings of affect state influencing stress responses are substantiated by previous literature on the increase in sensitivity to stimulus of the amygdala while individuals are in a negative affect state (Siegle et al. 2002; Rosenkranz et al. 2010). Also, the frequency of the pop-up messages in the study (one every 30 seconds) may not reflect a real-world human-computer interaction session. Finally, with the constraints imposed by the COVID-19 pandemic, we could not conduct the experimental sessions in a lab setting where an the researcher can exert more control over the surrounding environment. The sessions were rather conducted online, with participants performing the experimental task from their setting of choice. This led to differences task settings across participants. Nevertheless, we believe that the random assignment of participants to the experimental conditions has made these conditions comparable with regard to the differences in settings across participants. Also, conducting the study in participants' natural environment, rather than in an artificial lab setting, may have provided more support for external validity of our findings.

5.7 Future Research and Concluding Remarks

Future research calls for the use of other neurobiological methods for investigating the mechanisms and impact of technostress (e.g., EEG, fMRI). These instruments can help uncover other factors or mechanisms of stress that can be leveraged to reduce technostress. Also, the current study used pop-up messages as techno-stressor, and future studies may investigate how ICT users' responses to techno-stressors may differ across different types of stressors (e.g., slow system response time, system breakdown, difficulties in using an unfamiliar software or platform). Furthermore, given the evidence that affect states influence responses to potential techno-stressors, affect inductions methods need to be tested to identify the most effective ways for inducing positive affect to provide a level of resilience for dealing with techno-stressors. Additionally, research should investigate methods for providing agency to people to control their affect state or their response to stressors during human-computer interaction. Stress responses are often unconscious (Lovallo 2016). Pairing physiological sensors with ICT devices can help computer users monitor their affect state and stress levels and give them agency for enhancing their user experience and protecting their health (Zhang et al. 2019). Also, research should investigate whether there is a threshold of positive affect beyond which the resilience of the individual to technological stressors is significant. Likewise, there exists a threshold of negative affect state beyond which the stressful effect of the technological stimulus becomes significant. Finally, the current study has investigated the impact of affect state, a characteristic of the organism component in the Stress-Organism-Response (SOR) model, on users' responses to potentially stressful technological stimuli. Future research should examine other characteristics of the organism component in the SOR model that may influence users' responses to technological stressors (e.g., past exposure to similar stimulus, computer use self-efficacy).

Despite the research limitations and the constraints imposed by the COVID-19 pandemic during its implementation, this study makes a strong case for looking at the biological underpinnings of stress to alleviate the impact of technostress at work and in people's daily life; provides a start for interventions and devices to be developed for lessening technostress at work and in society.

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APPENDIX 1: Participants Recruitment Email

Greetings!

We are recruiting study participants, for our research "Toward A Framework for Alleviating Technostress." We would most appreciate your participation and help in conducting this research. Your participation is voluntary. We will provide a gift-card to compensate for your time in helping us. Please note that the study data will be anonymous and participants will not be personally identifiable.

What is required: During the research study, you will be asked
to interact through a computer. First, you will look at some pictures taken around the world. Thereafter, you will be asked to provide answers to problem-solving tasks. This session will be like other computer interactions with messages popping on the screen. Your face will be video recorded while you are performing the task.

You can participate if:
1) Your age is between 18 years and 60 years.
2) And you have normal or corrected vision.
How long will the session take? The entire session will be about one hour long.
What are the procedures in the study? The whole study will be conducted online. There are two main steps:

<u>Step 1:</u> After you agree to participate, you will be asked to click on a link to complete an online questionnaire. This will take 15 to 20 minutes. After you complete this questionnaire, you will be asked to contact the researcher to schedule the second step.

<u>Step 2</u>: This step will take place entirely on Zoom. You will be presented with pictures taken around the world. Afterwards, you will be asked to provide answers to problem-solving tasks while some random messages are popping up on the computer screen. Your face will be video recorded while you are performing the task.

The questionnaire and the experimental task can be completed on different times or days. After completion, we will send you an Amazon gift card as compensation for your time.
If you need additional information or want to schedule a time for your participation, please email your questions or available time to: contact email provided.

If you are willing to participate, please click on the link below to begin the first step (Step 1):

Baseline survey link provided

We thank you for your time.
The University of Oklahoma is an equal opportunity institution. (IRB # 13170)

APPENDIX 2: Experimental Task

Helping the Administration Make Sound Decisions

Background

You are asked to help the administration of a university in the South of the United states solve problems raised to them by students and employees from various departments of the university. As a student, your perspective is valuable to the administration in planning for future decisions.

Five problems presented below are brought to your attention. Feel free to use any help or software program on the program you may need (e.g. calculator, excel spreadsheet etc.) to answer the questions. Please, relax and take your time. Read them carefully and provide your answers that you think are the best for solving the issues.

Topic 1: Selecting the right videos for students at the Student Union

The Student Union at the university want to know what video materials are preferred by students when they come to the union for relaxation and mingling. At the end of each month, the Student Union officials check the number of views each video material has received. The table below presents the number of views per video for three months.

Video made available by the student union	January	February	March
1- Educational video of volcanic eruptions	600	650	700
2- Video of the history of bedlam football games with a rival university	700	700	700
3- A Movie of the most recent Star Wars saga	700	700	700
4- A two-hour video of various pop stars music	500	500	500
5- A documentary of favorite foods and recipes around the globe	400	500	400
6- A video showing how vast our universe is, with the billions of stars it contains	800	1000	1100
7- A video of the origin of the human species	1000	1200	1500
8- A video of a battle between a cobra and a mongoose	2000	2200	1800
9- A video-documentary on the 2008 financial crisis	200	150	100

Question: Which video had the lowest number of views?

← Input

Topic 2: Managing Parking Lots

The students have complained to the administration that the three main parking lots on campus are constantly full, causing them to be late for classes. The parking office delivers one specific permit for each parking lot, that is, if a student has a permit for Parking A, she can park on Parking A only. Expecting students not to be on campus all the time, the parking office had often issued more permits than spots available on a specific parking lot.

The table below provides the capacity of each parking lot (number of spots available) and the number of permits issued by the parking office. Please take a look at the table and answer the question below.

	Parking Lots Load Profiles					
	May	June	July	August	September	October
Parking A						
Capacity (spots available)	380	380	380	380	380	380
Permits Issued	400	380	440	360	280	300
Parking B						
Capacity (spots available)	330	330	330	330	330	330
Permits Issued	360	320	400	280	300	330
Parking C						
Capacity (spots available)	360	360	360	360	360	360
Permits Issued	420	300	400	340	320	360

Question: In which month (May to October) does it seem like there is the greatest demand for permits across all three parking lots?

Topic 3: Scheduling classes for the spring semester

The College of Business is asking you to help them schedule classes for the spring semester. Because of limited resources and the tight schedule of instructors, the college can offer only six (6) introductory classes for freshmen and sophomores this spring semester. The college is planning to offer the classes with the highest demand and for which an instructor is available. The table below presents some information on 12 classes, with the number of students expected to take the class and whether an instructor is available. Please select among the classes with available instructors the six classes with the highest number of students expected to take the class

Class	Number of students expected to take the class	Instructor available
Introduction to Finance	56	No
Information Systems I	43	Yes
Calculus for Business Applications	25	Yes
Business Ethics	43	No
Introduction to Business Statistics	19	Yes
Financial Accounting	39	Yes
Business Communication	27	Yes
Database Design	33	No
Principles of Marketing	28	Yes
Introduction to Programming	37	No
Principles of Management	45	Yes
Organizational Behavior	29	Yes

List the 6 classes you have selected. Remember that the instructor must be available to offer the class.

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Topic 4: Selecting the right university

College education is very expensive nowadays. A friend of yours has been accepted in 6 top universities to pursue her education in journalism. She is asking for your advice to help her choose, among the six journalism schools, the one that would fit better her finance.

	Tuition	Rent/Housing expenses	School fees	Other living expenses	Total Cost
University A	35,000	22,500	7,500	16,500	81,500
University B	45,000	13,000	6,000	14,500	78,500
University C	30,000	16,000	4,000	18,000	68,000
University D	33,000	17,000	5,000	15,000	70,000
University E	38,500	25,000	6,000	15,500	85,000
University F	34,000	17,000	6,500	16,000	73,500

Here are the financial decision rules:

1- **Total cost should be less than or equal to $78,500**
2- **Tuition should not be more than 50% of Total Cost**
3- **School fees should not be more than 10% of Total Cost**

Enter the universities you think she may consider, beginning with the lowest cost university that meets the financial decision rules.

1		**← Enter**
2		**← University**
3		
4		
5		
6		

Topic 5: Selecting scholarship recipients

You are member of a committee in charge of selecting excellent students to be awarded a scholarship from the Fred Johnson Foundation. Each scholarship is worth $500. There are three scholarships available and the list of potential recipients has been narrowed down to 10 students. The committee wants to award the three scholarships to the students who have the highest GPA and have not received the scholarship in previous years. If students are tied on their GPA scores, the advantage is given to the one with the largest amount of time dedicated to community service. The table below presents the information available on the 10 students.

Student Name	Current Overall GPA	Hours of community service/ month	Has previously received the scholarship
Homer Ayunle	3.74	5	Yes
Mary Bersky	3.65	0	No
Lin Chuan	3.93	0	Yes
David Johnson	3.52	10	No
Ali Koffi	3.91	3	No
Jessica Broderick	3.78	12	Yes
Alan Pickford	3.62	0	No
Willie Marshal	4.0	2	Yes
Jane Emory	3.65	6	No
Ti’Shuan Bell	3.79	7	No

Decision rule: 1) Th student has not received the scholarship in previous years
2) The student has higher GPA score than that of others
3) If students are tied on GPA scores, the one with the largest number of hours in community service is selected

Please indicate the names of the three students who should be selected as recipients of the scholarship.

1)--

2)---

3)---

Topic 6: Assigning rooms for classes

The director of the information systems division asks you to assign a list of five classes to the rooms that are the most convenient for teaching the courses. Since each class has different requirements and number of enrolled students.

Table 1: Classes to be offered

Classes	Number of enrolled students	Schedule
Information Systems I	35	Monday 3:00 pm – 6:00 pm
Database Design	23	Wednesday 9:00 am – 12:00 pm
Introduction to Computer Programming	27	Tuesday 11:00 am – 2:00 pm
Business Applications in Excel	45	Monday 1:00 pm – 4:00 pm
Systems Analysis and Design	32	Tuesday 9:00 am – 12:00 pm

Table 2: Capacity and availability of rooms

Room	Capacity (number of available seats)	Availability (Time in the week)
Room A	45	Tuesday 8:00 am - 3:00 pm Thursday 3:00 pm – 6:00 pm
Room B	60	Monday 8:00 am – 1:00 pm Thursday 12:00 pm – 9:00 pm
Room C	40	Monday 12:00 pm – 6:00 pm Friday 8:00 am – 2:00 pm
Room D	15	Monday 9:00 am – 4:00 pm Tuesday 12:00 pm – 4:00 pm
Room E	40	Monday 12:00 pm – 4:00 pm Tuesday 9:00 am – 12:00 pm
Room F	35	Wednesday 1:00 pm – 6:00 pm Friday 9:00 am – 2:00 pm
Room G	60	Monday 1:00 pm – 9:00 pm Wednesday 8:00 am – 1:00 pm

Please, indicate the room you are assigning to each class:

Information Systems I: --

Database Design: --

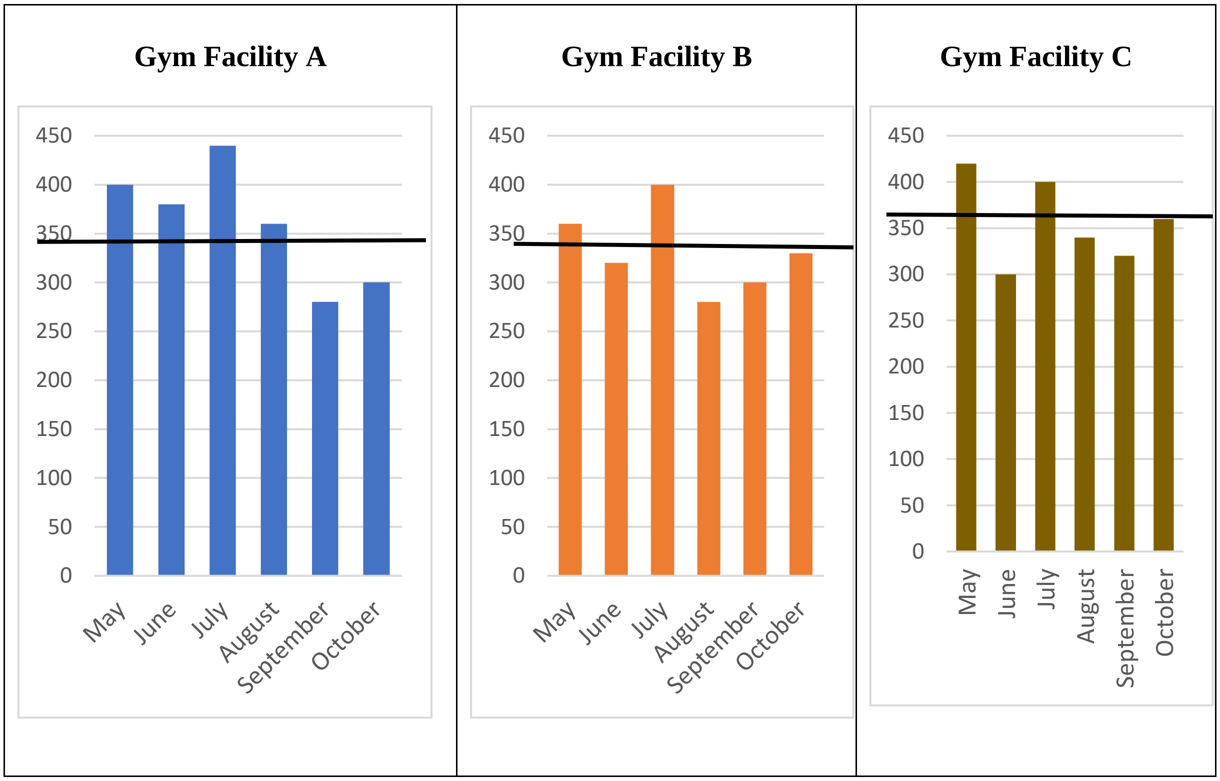
Introduction to Computer Programming: --

Business Applications in Excel: --

Systems Analysis and Design: --

Topic 7: Managing Usage of Gym Facilities

At the university, there are three main gym facilities on campus. Each of these facilities is well liked and used by students throughout the year. The total capacity (i.e. the number of people that can use the gym per day) varies by facility (black line on the graphs below). The three graphs below present the average daily number of students using each facility from May through October.



Question: What is the excess capacity for Gym Facility C in the month of July?

You Have Reached the End of The Tasks.

Thank You Very Much for Your Participation

APPENDIX 3: The Positive Affect Negative Affect Scale (PANAS)

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent [INSERT APPROPRIATE TIME INSTRUCTIONS HERE]. Use the following scale to record your answers.

1= very slightly or not at all   2=a little   3= moderately   4=quite a bit   5=extremely

I have felt this way when listening to the piece of music that was played:

_______Interested	_______Irritable
_______Distressed	_______Alert
_______Excited	_______Ashamed
_______Upset	_______Inspired
_______Strong	_______Nervous
_______Guilty	_______Determined
_______Scared	_______Attentive
_______Hostile	_______Jittery
_______Enthusiastic	_______Active
_______Proud	_______Afraid

APPENDIX 4: Stress Appraisal Measure (SAM)

This questionnaire is concerned with your thoughts about **the pop-up messages that appear on the computer screen while you were completing the task**.

There are no right or wrong answers. Please respond according to how you view this situation right NOW. Please answer ALL questions. Answer each question by CIRCLING the appropriate number corresponding to the following scale.

1	**2**	**3**	**4**	**5**
Not at All	Slightly	Moderately	Considerably	Extremely

Controllable-by-self					
1. Do I have the ability to do well even with these pop-ups?	1	2	3	4	5
2. Do I have what it takes to do well despite these pop-ups?	1	2	3	4	5
3. Will I be able to overcome the problem caused by these pop-ups?	1	2	3	4	5
4. Do I have the skills necessary to achieve a successful outcome to this situation?	1	2	3	4	5
Threat					
5. Do these pop-ups make me feel anxious?	1	2	3	4	5
6. Will the outcome of this situation be negative?	1	2	3	4	5
7. How threatening is this situation?	1	2	3	4	5
8. Are these pop-ups going to have a negative impact on me?	1	2	3	4	5

APPENDIX 5: Coping Questionnaire (BRIEF COPE)

What were my usual reactions when my computer screen was flooded with pop-up messages while I was performing the task: **Possible Answers:** **1 = I have not been doing this at all** **2 = I have been doing this a little bit** **3 = I have been doing this a medium amount** **4 = I have been doing this a lot**
Self-distraction
1. I have been turning to work or other activities to take my mind off things.
19. I have been doing something to think about it less, such as going to movies, watching TV, reading, daydreaming, sleeping, or shopping.
Active coping
2. I have been concentrating my efforts on doing something about the situation I'm in.
7. I have been taking action to try to make the situation better.
Denial
3. I have been saying to myself "this isn't real.".
8. I have been refusing to believe that it has happened.
Use of emotional support
5. I have been getting emotional support from others.
15. I have been getting comfort and understanding from someone.
Use of instrumental support
10. I have been getting help and advice from other people.
23. I have been trying to get advice or help from other people about what to do.
Behavioral disengagement
6. I have been giving up trying to deal with it.
16. I have been giving up the attempt to cope.
Venting
9. I have been saying things to let my unpleasant feelings escape.
21. I have been expressing my negative feelings.
Positive Reframing
12. I have been trying to see it in a different light, to make it seem more positive.
17. I have been looking for something good in what is happening.
Planning
14. I have been trying to come up with a strategy about what to do.
25. I have been thinking hard about what steps to take.
Humor
18. I have been making jokes about it.
28. I have been making fun of the situation.

Acceptance
20. I have been accepting the reality of the fact that it has happened.
24. I have been learning to live with it.
Self-blame
13. I have been criticizing myself.
26. I have been blaming myself for things that happened.

APPENDIX 6: Attention-To-Task Questionnaire

This questionnaire surveys how much attention you paid while performing the task. There are eight (8) questions with possible answers on a scale from 1 (Strongly Disagree) to 7 (Strongly Agree). There is no right or wrong answer. Please provide an honest answer for each of these 8 questions.

	Strongly Disagree	Moderately disagree	Slightly Disagree	Neither Disagree Nor agree	Slightly Agree	Moderately Agree	Strongly Agree
1. I focused my total attention on making fewer errors in performing the task	1	2	3	4	5	6	7
2. I focused my total attention on finding rules to perform the task	1	2	3	4	5	6	7
3. I focused my total attention to being ready to using a new approach to perform the task	1	2	3	4	5	6	7
4. I focused my total attention to solving as quickly as I could	1	2	3	4	5	6	7
5. I focused my total	1	2	3	4	5	6	7

attention to responding quickly to what I saw							
6. I focused my total attention to performing the task	1	2	3	4	5	6	7
7. I daydreamed while doing the task	1	2	3	4	5	6	7
8. I let my mind wander while doing the task	1	2	3	4	5	6	7

APPENDIX 7: Background Questionnaire

Please answer the following questions candidly. None of this will be used in the research but is primarily intended to know the general background of our participants.

Please write or check the appropriate answers.

Gender: M □ F □ Age: _______ years

Are you a business major? Yes □ No □

MAJOR: ___________________________________

STATUS: Freshman □ Sophomore □ Junior □ Senior □ Master □ PhD □

Cumulative GPA: _________

1. In approximately how many classes have you used computers? ________
2. How many classes have you taken where computer / software programming courses have been taught? _________
3. When did you first use a computer? (Check one)

   This year □

   Within the past two years □

   More than two years ago □

4. Approximately how many hours a week do you use a computer?

   Less than 5 hours □ 5 to 10 hours □ More than 10 hours □

5. Do you own a personal computer? Yes □ No □

6. How often do you exercise physically?

……………………time (s) per week

7. What type of physical exercise do you practice when you exercise? Check all that apply.

   Walking outside □

   Running outside □

Walking on a treadmill ◻

Running on a treadmill ◻

Yoga ◻

Riding a bicycle ◻

Team sport (Basketball, Soccer, volleyball etc. ◻

Swimming ◻

Weightlifting ◻

Other, please specify …………………………………

APPENDIX 8: Perceived Stress Scale

For each question choose from the following alternatives:

0 – never 1 - almost never 2 – sometimes 3 - fairly often 4 - very often

______ l. In the last month, how often have you been upset because of something that happened unexpectedly?

______ 2. In the last month, how often have you felt that you were unable to control the important things in your life?

______ 3. In the last month, how often have you felt nervous and stressed?

______ 4. In the last month, how often have you felt confident about your ability to handle your personal problems?

______ 5. In the last month, how often have you felt that things were going your way?

______ 6. In the last month, how often have you found that you could not cope with all the things that you had to do?

______ 7. In the last month, how often have you been able to control irritations in your life?

______ 8. In the last month, how often have you felt that you were on top of things?

______ 9. In the last month, how often have you been angered because of things that happened that were outside of your control?

______ 10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

APPENDIX 9: Multitasking Subscale of the Digital Natives Assessment Scale

	Comfortable with Multitasking	
1	I can chat on the phone with a friend and message another at the same time	
2	I am able to surf the Internet and perform another activity comfortably	
3	I am able to communicate with my friends and do my work at the same time.	
4	I can check email and chat online at the same time.	
5	When using the Internet for my work, I am able to listen to music as well.	

APPENDIX 10: Emotional Stability Subscale of the International Personality Item Pool (IPIP)

Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence.

		Very Inaccurate	**Moderately Inaccurate**	**Neither Accurate Nor Inaccurate**	**Moderately Accurate**	**Very Accurate**
	Emotional Stability					
1	Get stressed out easily.					
2	Worry about things.					
3	Am easily disturbed.					
4	Get upset easily.					
5	Change my mood a lot.					
6	Have frequent mood swings.					
7	Get irritated easily.					
8	Often feel blue.					
9	Am relaxed most of the time.					
10	Seldom feel blue.					

APPENDIX 11: Rotter's Internal-External Locus of Control Scale (1966)

Indicate the extent to which you agree with the statements below.

Item	Check
1.a. Children get into trouble because their parents punish them too much.	**Filler**
1.b The trouble with most children nowadays is that their parents are too easy with them.	**Filler**
2.a. Many of the unhappy things in people's lives are partly due to bad luck.	
2.b People's misfortunes result from the mistakes they make.	
3.a. One of the major reasons why we have wars is because people do not take enough interest in politics.	
b. There will always be wars, no matter how hard people try to prevent them.	
4.a. In the long run people get the respect they deserve in this world.	
b. Unfortunately, an individual's worth often passes unrecognized no matter how hard he tries.	
5.a. The idea that teachers are unfair to students is nonsense.	
b. Most students do not realize the extent to which their grades are influenced by accidental happenings.	
6.a. 'Without the right breaks one cannot be an effective leader.	
b. Capable people who fail to become leaders have not taken advantage of their opportunities.	
7.a. No matter how hard you try some people just don't like you.	
b. People who cannot get others to like them do not under- stand how to get along with others.	
8.a. Heredity plays the major role in determining one's personality.	**Filler**
b. It is one's experiences in life which determine what they're like.	**Filler**
9.a. I have often found that what is going to happen will happen.	
b. Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.	
10.a. In the case of the well prepared student there is rarely if ever such a thing as an unfair test.	
b. Many times, exam questions tend to be so unrelated to course work that studying is really useless.	
11.a. Becoming a success is a matter of hard work, luck has little or nothing to do with it.	
b. Getting a good job depends mainly on being in the right place at the right time.	
12.a. The average citizen can have an influence in government decisions.	
b. This world is run by the few people in power, and there is not much the little guy can do about it.	
13.a When I make plans, I am almost certain that I can make them work.	

Item	Check
b. It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.	
14.a. There are certain people who are just no good.	**Filler**
b. There is some good in everybody.	**Filler**
15.a. In my case, getting what I want has little or nothing to do with luck	
b. Many times we might just as well decide what to do by flipping a coin.	
16.a. Who gets to be the boss often depends on who was lucky enough to be in the right place first?	
b. Getting people to do the right thing depends upon ability, luck has little or nothing to do with it.	
17.a. As far as world affairs are concerned, most of us are the victims of forces we can neither understand, nor control	
b. By taking an active part in political and social affairs the people can control world events.	
18.a. Most people don't realize the extent to which their lives are controlled by accidental happenings.	
b. There really is no such thing as "luck."	
19.a. One should always be willing to admit mistakes.	**Filler**
b. It is usually best to cover up one's mistakes.	**Filler**
20.a. It is hard to know whether or not a person really likes you.	
b. How many friends you have depends upon how nice a person you are.	
21.a. In the long run the bad things that happen to us are balanced by the good ones.	
b. Most misfortunes are the result of lack of ability, ignorance, laziness, or all three.	
22.a. With enough effort, we can wipe out political corruption.	
b. It is difficult for people to have much control over the things politicians do in office.	
23.a. Sometimes I can't understand how teachers arrive at the grades they give.	
b. There is a direct connection between how hard I study and the grades I get.	
24.a. A good leader expects people lo decide for themselves what they should do.	**Filler**
b. A good leader makes it clear to everybody what their jobs are.	**Filler**
25.a. Many times, I feel that I have little influence over the things that happen to me.	
b. It is impossible for me to believe that chance or luck plays an important role in my life.	
26a. People are lonely because they don't try to be friendly.	
b. There's not much use in trying too hard to please people, if they like you, they like you.	
27,a. There is too much emphasis on athletics in high school.	**Filler**
b. Team sports are an excellent way to build character.	**Filler**

Item	Check
28.a. What happens to me is my own doing.	
b. Sometimes I feel that I do not have enough control over the direction my life is taking.	
29.a. Most of the time I cannot understand why politicians behave the way they do.	
b. In the long run the people are responsible for bad government on a national as well as on a local level.	