12-12-2022

Fatigue in Information Technology Use: Definition, Measurement, and Its Effects on Performance

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ABSTRACT

Fatigue, a prevalent symptom in today's general population, has been found to play a critical role in individuals' well-being, health, and occupational outcomes. The relationship between information technology (IT) and fatigue has long been investigated in psychological literature, whereas the IS field has paid insufficient attention to this topic. The present research aims to conceptualize IT fatigue and examine its impact on users' task performance. Drawing upon the theory of fatigue from the cognitive psychology discipline, we propose four dimensions of IT fatigue: general IT fatigue, reduced motivation to use IT, reduced concentration on IT, and physical IT fatigue. Further, we argue that IT mindfulness can potentially reduce users' IT fatigue and at the same time moderate the relationship between IT fatigue and task performance. It is expected that the investigation into the IT-induced fatigue phenomenon will assist future research on fatigue in the context of human-technology interaction.

Keywords

Fatigue, IT fatigue, IT mindfulness, task performance, compensatory control model.

INTRODUCTION

Fatigue has been conceptualized as a functional state that arises when an individual's internal or external demands exceed available resources (Aaronson et al., 1999). It is highly prevalent in every aspect of modern life, from occupational to medical settings (Christodoulou, 2017). Research finds that fatigue plays a crucial role in burnout and job turnover (Demerouti et al., 2001) and can cause negative effects on well-being and health outcomes (Hockey, 2013). A National Safety Council (NSC) survey (2018) found that two-thirds of the labor force in the US are affected by occupational fatigue. This number equates to around 107 million out of 160 million US employees experiencing fatigue issues. More severely, long-term effects of prolonged subjective fatigue have been implicated in health issues (Swain, 2000). It is evident that fatigue is a serious problem with negative consequences.

Excessive technology use has been identified as a major source of fatigue (Lee et al., 2016). Information technology (IT) has been increasingly utilized as an effective tool for obtaining valuable information, performing relevant tasks, and fulfilling various personal or professional goals (Bassellier et al., 2001). Along with the extensive use of IT, academic research on the effect of technology use on individuals' feelings of fatigue is beginning to emerge. For instance, Bright et al. (2015) explored the concept of social media fatigue, which was defined as users' reluctance to engage in social media when they become overwhelmed with information. Confronting the occurrence of "Zoom Fatigue" due to the COVID-19 pandemic, researchers have studied Zoom fatigue and explored its antecedents and consequences (Fauville et al., 2021). For example, Wiederhold (2020) pointed out that technology can disrupt people's normal in-person communication through online videoconferencing, which can be much more mentally exhausting. More recently, Mueller and Benlian (2022) drew on ego depletion theory and the notion of self-regulatory resources to examine effect of an agile information systems development approach on developers' feelings of fatigue and ultimately turnover intention.

Although there is a growing body of research on connections from fatigue to a specific type of technology, the investigation into the effects of general IT-induced fatigue on individuals' subsequent responses is unknown. Given that the use of IT has become ubiquitous and users' negative cognitive responses to IT have been increasingly reported by researchers (Ayyagari et al., 2011), the development of an IT-specific fatigue concept is important. Specifically, conducting research on IT fatigue contributes to the literature on the "dark side" of technology use, which has primarily focused on computer anxiety and technostress (Thatcher & Perrewe, 2002). In addition, there have been calls for developing interventions to reduce users' negative cognitive responses toward technology (Tarafdar et al., 2013). In response, the present study aims to examine the effects of IT fatigue on users' behavioral outcomes and to identify coping strategies that can help users overcome IT fatigue.

The decrement in a person's physical and mental performance has long been recognized as an outcome of being fatigued (Grandjean, 1979). Substantial research has shown that fatigue, which serves as an urge to stop exerting further effort on a given task or to decrease task engagement, has a negative influence on individuals' task performance (Åhsberg, 1997). In an attempt to examine whether fatigue changes the way people explore a complex computer system and affects performance, van der Linden et al. (2003) conducted an experiment and found that fatigued individuals were less thoughtful and reflective in their computer exploration behavior. Also, the results have shown that fatigue can lead to observable changes in users' task performance, such as a higher frequency of making errors. They particularly pointed out that the overt decline in task performance during computer exploration was consistent with previous research on fatigue studies (Hockey, 1997).

Further, it is important to point out that the human mind can be highly adept at regulating and managing thoughts, decisions, and actions. Mindfulness, one of the most crucial forms of self-regulation, has been extensively adopted as a strategy to reduce individuals' cognitive vulnerability to fatigue in contemporary psychology (Kaplan et al., 1993). Self-regulation of attention is one of the factors that account for the fatigue-reducing effects of mindfulness. With a high level of mindfulness, people are able to strengthen their awareness of the current experience by regulating their focus of attention, also known as sustained attention (Bishop et al., 2004). Individual differences with regard to diverse levels of sustained attention could determine individuals' fatigue condition. In the technology use context, Thatcher et al. (2018) argued that IT mindfulness, a dynamic IT-specific trait, can exert a relatively enduring effect on individuals' interactions with a given technology. According to Hockey's (1993, 1997, 2011) Compensatory Control Model (CCM), one of the dominant theories emphasizing self-regulatory control mechanisms, a high level of controllability with regard to attention, motivation, and resource allocation can positively affect an individual's overt performance under fatigue states. In light of the mindfulness literature and CCM, we argue that IT mindfulness could be a coping strategy that helps users overcome IT fatigue. The objectives of the current research are:

- To examine the negative effect of IT fatigue on users' task performance; and
- To examine the role of IT mindfulness in reducing IT fatigue and its role in moderating the effect of IT fatigue on users' task performance.

The present study attempts to contribute to the IS literature in several ways. First, the state of fatigue merits further exploration in IS research. For decades, IS scholars have paid considerable attention to examining the indicators and consequents of technology-related stress and have established a valuable research program in this area (e.g., Ayyagari et al., 2011). From a psychological view, stress is associated with numerous affective states, including fatigue. Nonetheless, stress and fatigue are typically treated as distinct states and measured differently (Matthews & Desmond, 2002). Moreover, research shows that stress responses as a purely biological model that can proceed without being perceived (Szabo et al., 2012). However, under the "fatigue as a marker of alertness or functional state" approach, the perception of tiredness is a hallmark of being fatigued (Olson, 2007, p. 94). The second contribution of this study is to advance our knowledge of both the methods for capturing the subjective state of fatigue in technology use and the impact of such state on individuals. It is essential to recognize that if we want to predict the effects of IT fatigue on users and seek to mitigate its adverse effects, we must understand how individuals would psychologically respond when users experience IT fatigue.

THEORETICAL FOUNDATIONS

IT Fatigue: Definition and Dimensions

The definition of fatigue varies, and there is no consensus on how it should be evaluated (Aaronson et al., 1999). In general, there are two distinct perspectives to conceptualizing fatigue. From a physiological standpoint, fatigue can refer to "a loss of maximal force-generating capacity that develops during muscular activity" (Lewis & Haller, 1991, p. 98). From a psychological perspective, subjective feelings of fatigue refer to the individual's conscious experience of energy depletion and a state of weariness coupled with diminished motivation (Aaronson et al., 1999). Scholars tend to adopt multidimensional fatigue scales, which they believe are more capable of exploring the complex nature and wider experience of fatigue (Smets et al., 1995; Fisk et al., 1994).

In this paper, we describe IT fatigue as an individual's subjective feeling of tiredness because of the cognitively demanding nature of technology use (Åhsberg et al., 1997). We define IT fatigue as a psychological and physiological state characterized by decreased capacity and motivation to maintain the original goal of using IT. It is widely accepted that IT use involves a high level of cognitive processes (i.e., executive functions) to learn and operate the target system (Sullivan et al., 2022), and users' psychological states can substantially affect the outcomes of system use. To better capture the breadth and complexity of the fatigue state in technology use, we conceptualize IT fatigue as a multidimensional construct. We conceptualize IT fatigue as a formative construct because each dimension captures differing aspects of IT fatigue. Specifically, *General IT fatigue* is characterized by a lack of energy caused by IT use, including feelings of tiredness, being drained, worn out, and sleepy (Åhsberg et al., 1997). It describes a general feeling of being in poor condition, weak, and desiring rest after prolonged technology use.

Reduced motivation to use IT is concerned with a lack of internal forces that influence one's choice of IT-related action. For example, a fatigued user may lose interest in starting or continuing the technology-related task at hand, feel passive to do anything, or want to switch to another activity (Smets et al., 1995).

Reduced concentration on IT incorporates the processes of attentional control, effort allocation, and thinking when dealing with IT-related activities. As noted by Fisk et al. (1994), fatigue may impair individuals' ability to concentrate on a specific task, slow down their thinking processes, and make them feel less alert or more forgetful.

Physical IT fatigue refers to an individual's reduction in the physical effort being exerted for an IT-related activity. This dimension incorporates the diverse physical symptoms linked with IT use. A subjective rating of physical IT fatigue can be measured through items such as "can do a little or can take on a lot of IT-related tasks" and "have trouble maintaining physical effort on IT-related tasks" (Fisk et al., 1994). Besides, physical IT fatigue is frequently accompanied by a set of unpleasant body feelings generated by technology use, such as the neck, shoulder, wrist, and back pain, tense muscle, numbness, and eyestrain (Åhsberg, 1997).

Compensatory Control Model

A crucial and yet unaddressed issue in the study of fatigue pertains to whether and how subjective judgments and feelings of fatigue exert an influence on individuals' performance over time on task. One prominent approach to account for differential effort and control in relation to performance under a fatigued state is Hockey's compensatory control model (Hockey, 1993, 1997, 2011). The CCM was originally developed to account for individuals' performance under demanding conditions such as stress and high workload (Hockey, 1993, 1997) but has been subsequently expanded to accommodate the unique impacts of fatigue (Hockey, 2011). One of the essential assumptions of the CCM is that the role of the individual is an active agent, making decisions about how to cope with task demands. People have a variety of compensatory and coping methods at their disposal for preventing fatigue-related performance declines (Hockey, 1997). According to the CCM, a person's compensatory trade-off between effort and cognitive goals exerts a particularly strong influence on how he or she manages performance under fatigue. For instance, individuals can concentrate on the most critical component of the task while ignoring subsidiary aspects; they can switch to less effortful tactics, or they can make compromises, such as speed against accuracy. Besides, people can also use compensatory effort to overcome the effects of fatigue.

In this research, we propose IT mindfulness can be a potential coping strategy that individuals engage in to prevent fatigue-related performance declines. Prior research indicates that IT mindfulness is characterized by a high level of self-regulation of attention to IT-related details and a high motivation to seek alternative or innovative usage of IT (Thatcher et al., 2018). For instance, an individual with a high level of IT mindfulness is more likely to be thoughtful and to conduct systematic IT-related exploration, which is believed to allow them constantly focus on the critical aspect of a computational task rather than the peripheral one. Besides, strategic attention allocation can enable them to achieve a better or longer sustained performance than people with a low level of IT mindfulness.

RESEARCH MODEL & HYPOTHESES DEVELOPMENT

To build the conceptual framework for our study (Figure 1), we draw upon the CCM proposed by Hockey (1993, 1997, 2011). The central assumption of CCM is that the observed stability in performance under fatigue is an active process under the control of the individual, requiring the distribution of cognitive resources through the mobilization of mental effort. Those with high IT mindfulness are likely to experience less fatigue, and IT mindfulness can also weaken the negative effect of IT fatigue on task performance.

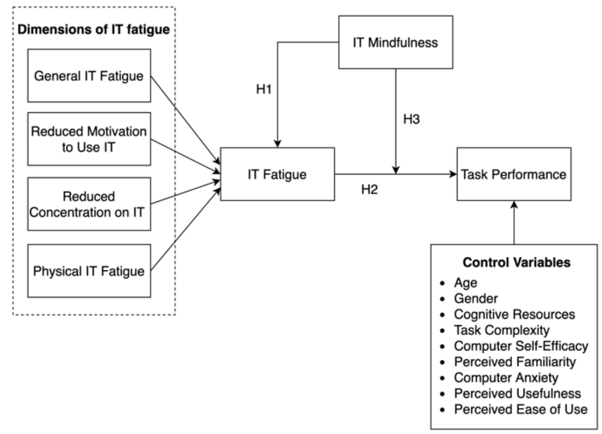

Figure 1. Research Model

Hypothesis 1: IT mindfulness negatively affects individuals' IT fatigue.

Hypothesis 2: IT fatigue has a negative relationship with task performance.

Hypothesis 3: IT mindfulness negatively moderates the negative relationship between IT fatigue and task performance. Specifically, the negative effect of IT fatigue on task performance is stronger among those with low IT mindfulness relative to among those with high IT mindfulness.

METHODOLOGY

To test the hypotheses mentioned above, we will conduct two empirical studies. Study 1 will test the relationships among IT fatigue, IT mindfulness, and task performance in a classroom or computer lab environment. In Study 2, we will integrate eye-tracking techniques to investigate the direction of participants' gaze when they are experiencing IT fatigue.

Study 1

In this study, we will conduct a field experiment in an actual classroom or computer laboratory setting. Students enrolled in the introduction to programming course will be asked to participate. The week(s) when the instructor will cover the materials that require participants to engage intensely with the computer will be treated as the experimental condition to induce IT fatigue. The researchers will work with the class instructor to design an appropriate computer assignment that can potentially induce fatigue for those specific lab sessions. To create a low IT fatigue condition, our study will use the same subjects (i.e., within-subjects factor) during the week(s) when the course instructor will discuss the materials that require less interaction with the computer relative to the sessions used to induce high IT fatigue. As a control condition, the design of the study will also recruit students who take courses in a regular classroom setting (non-computer lab) where their interaction with a computer device is very minimum. We will work with the class instructor to ensure the level of task complexity of various sessions is equally comparable.

Prior to the class session, participants will be asked to complete a pre-task questionnaire consisting of questions about their general health, their daily fatigue experience, Raven's advanced progressive matrices (Raven et al. 1998) to measure their cognitive resources, and demographic questions. After a class or computer lab session that will last approximately an hour, participants will be asked to complete the IT fatigue, IT mindfulness, as well as task complexity questionnaire. Their scores on the assigned class exercises will be used as an indicator of their task performance.

Study 2

The primary purpose of Study 2 is to integrate eye-tracking techniques to test our hypotheses and validate our findings. Eye-tracking methods have the advantage of being unobtrusive, and they were employed in the majority of prior studies and applications aiming to monitor fatigue through psychophysiological measures (Dawson et al., 2014).

Study 2 will take place in a computer lab. We will induce IT fatigue using a time-on-task paradigm and introduce alternative stimuli to the experimental environment (Hopstaken et al., 2016). Specifically, participants will be asked to complete a prolonged computer task. Following Hopstaken et al. (2006), we will present images of faces on the far sides of the screen during the experiment. According to prior research, faces are relatively rewarding to look at even when they are not task-relevant because they may contain social information and have some evolutionary adaptive role (Hopstaken et al., 2006). Thus, eye-tracking can be used to observe participants' focus of gaze with increasing time-on-task and IT fatigue.

During the study, we will also monitor subjective ratings of IT fatigue, IT mindfulness, psychological indicators of participants' focus of gaze (i.e., P3 amplitude and baseline pupil diameter), and their task performance. Together, the combination of these measures allows us to test our hypotheses.

EXPECTED CONTRIBUTIONS

The investigation into IT fatigue can contribute to the existing literature on the "dark side" of technology use. This present research will be a response to the calls for papers developing interventions and coping strategies aimed at reducing negative cognitive responses to technology among users. Moreover, the current work will have multiple practical implications. First, this study aims to examine the psychological and cognitive responses of an individual when facing IT-fatigued situations. If we could discover factors that significantly affect an individual's responses to IT fatigue, we would be in a much better position to prevent serious consequences caused by IT fatigue, such as failure of system operation or chronic mental fatigue. Second, understanding factors that can assist in reducing negative influences of IT fatigue on individuals' work and personal lives can improve IT users' and IT professionals' quality of life, well-being, and occupational outcomes. In an effort to examine more thoroughly the fatigue states induced by IT, we aim to employ an adapted IT fatigue measurement and multiple research approaches to fulfill our goal of the study – to help users overcome the fatigue state caused by technology use.

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