4-23-2018

Mindfulness as a vigilance intervention: Examining its impact on stress and mental demand

Kelli Huber
kh6g2@mail.umsl.edu

Mindfulness as a vigilance intervention:

Examining its impact on stress and mental demand

by

Kelli E. Huber
M.A., Industrial/Organizational Psychology, University of Missouri – St. Louis, 2013
B.A., Psychology, Saint Louis University, 2011

A Dissertation Submitted to The Graduate School at the University of Missouri – St. Louis in partial fulfillment of the requirements for the degree Doctor of Philosophy in Industrial and Organizational Psychology

2018

Advisory Committee

Stephanie Merritt, Ph.D.
Chair

John Meriac, Ph.D.

Jeffrey Noel, Ph.D.

Matthew Taylor, Ph.D.

Abstract

Occupations involving vigilance performance (i.e., sustained attention in monitoring for rare environmental threats) are known to experience vigilance decrement, a decline in performance over time. These occupations are known to be cognitively and emotionally challenging, giving rise to harmful effects for employees in them and presenting safety implications for the welfare of others. The current study investigated mindfulness as a potentially viable intervention to alleviate outcomes of vigilance demands: stress and mental demand. A mindfulness induction was compared to an unfocused control condition in which both were administered during a break from a vigilance task, specifically, a baggage screening task. Ultimately, findings did not reveal positive effects for the mindfulness intervention, leading to reservations about its viability in a vigilance context. Moderation analyses revealed that baseline levels of stress and mental demand may have impacted one's ability to derive benefits from the mindfulness intervention. Finally, though the intervention failed to take effect, promising findings emerged for general levels of trait and state mindfulness across participants, independent of condition. Implications and future research directions are discussed. `

Keywords: mindfulness, vigilance decrement, safety, stress, working memory, mental demand, performance

Acknowledgments

I want to express a heartfelt thanks to the people who helped me along this journey. To Stephanie, thank you so much for your time, support, and insights throughout this project. I am thankful not only for your guidance throughout my dissertation but throughout all of my graduate school experience. To all of my committee members (Stephanie, John, Jeff, and Matt), I am grateful for your time and for your collective brain power that helped this project take shape. Thank you to all of the I/O faculty who were so supportive in other ways throughout this graduate school journey. I will be forever grateful to you for offering your wisdom and for shaping me into a better psychologist (& person). To Mary Jo and to my amazing research assistants, McKayla and Yakcob, thank you for going above and beyond to lend a hand and to make data collection go more smoothly.

To my fellow graduate students, I would not have made it without you! I cannot believe how fortunate I am to have met so many smart and amazing humans like you along the way. Thank you for the support and the laughs. I especially want to thank my most trusted confidants – my cohort (Sarah, Ryan, Rob, and Matt), other graduate students (Jess, Ashley, Debbie, Jenny, and Amanda), and my entire work family. Finally, thank you to my family and other friends for their unconditional love, encouragement, and patience along this crazy ride. I know you are overjoyed to no longer have to ask what year in school I am.

Table of Contents

List of Tables

List of Figures

List of Appendices

Mindfulness as a Vigilance Intervention:

Examining its Impact on Stress and Mental Demand

Numerous safety-critical occupations such as counterterrorism screenings and medical monitoring call for *vigilance performance:* sustained periods of attention requiring one to stay alert to uncommon yet threat-related stimuli over an extended period of time (Davies & Parasuraman, 1982; Parasuraman, 1986). In these contexts, human error has potentially dangerous consequences, not only to individual employees but to public safety as a whole. Well-known examples resulting in such outcomes include the actions of nuclear power plant operators in the Three Mile Island accident and of flight crews in recent aviation accidents such as Asiana Flight 214 and Air France Flight 447. Despite potential life-or-death implications, evidence indicates humans have limited ability to sustain long periods of vigilance (Davies & Parasuraman, 1982) as these tasks and occupations can be quite cognitively and psychologically taxing (Smit, Eling, Coenen, & 2004; Warm, Parasuraman, & Matthews, 2008). To address calls for research to examine methods of assuaging such effects, this research investigated *mindfulness* as a means of recovery from stress and mental demand in a vigilance context.

In recent decades, increased attention has been devoted to the study of mindfulness. It is conceptualized by three core elements: 1) staying present to the "here and now," 2) paying attention to both internal (e.g., thoughts, feelings) and external stimuli (e.g., audio, visual) and finally, 3) doing so in a receptive way, without judging or cognitively manipulating one's experiences (Brown, Ryan, & Creswell, 2007). Hyland, Lee, and Mills (2015, p. 5) effectively capture the essence of mindfulness when they contend that, "Although we may think that we naturally experience our surroundings as they are, this is rarely the case. Most of the time our perception is limited by our attention span; fragmented by continuous distractions; distorted by our biases, assumptions, and expectations; and regularly hijacked by our emotional reactivity." They go on to assert that mindfulness cultivates an ability to better elude these limitations, promoting a more lucid picture of one's everyday experiences.

In recent decades, mindfulness has flourished and received significant attention among clinical psychologists as well as medical researchers and practitioners for its benefits to physical and psychological health (e.g., stress in cancer patients, chronic pain, depression, insomnia, cellular aging, immune system functioning; Baer, 2003; Davidson et al., 2003; Carlson & Garland, 2005; Epel, Daubenmier, Moskowitz, Folkman, & Blackburn, 2009; Ong & Sholtes, 2010). Only in the past several years has mindfulness garnered empirical attention in the workplace as researchers and practitioners began to observe what it brings to this domain. Studies have uncovered mindfulness' positive outcomes in areas such as stress, emotional intelligence, job satisfaction, and working memory capacity, conflict management (Hyland et al., 2015; Hülsheger, et al., 2013; Long & Christian, 2015)

The goal of this study was to extend this research and answer calls (e.g., Helton & Russell, 2011; Huber, Hill, & Merritt, 2015) to examine *mindfulness* as a recovery activity in a safety context and lever for improving vigilance performance. More specifically, the study examined it as a potential buffer against the negative impact of vigilance tasks on stress and mental demand. In doing so, it could serve as a practical, inexpensive, and effective means of improving performance on safety-critical tasks. I will begin by reviewing literature on the vigilance decrement, including processes by which it is thought to operate and current methods used to safeguard against it. Following that, I will discuss mindfulness in more detail and hypothesize how mindfulness interventions may target the processes implicated in the vigilance decrement.

Background of Vigilance Research

Early research on vigilance performance was conducted by Mackworth (1948), a neurologist and human factors psychologist, during World War II. He studied radar and sonar operators on patrol to look for enemy submarines. In his work, he made a unique observation. The operators had a propensity to miss signals near the end of their watch, thus leaving Allied ships vulnerable to attack. Finding this observation perplexing, Mackworth was commissioned to uncover why.

To examine this pattern, Mackworth created a simulated radar display labeled the "Clock Test." Over the course of two hours, he instructed participants to monitor a black pointer on a blank-faced clock. This pointer made small movements approximately every second, and on occasion, the pointer would make a "double jump." When this happened, participants were instructed to press a button. Mackworth confirmed his predictions based on what he witnessed previously in the field. He noticed that accuracy starkly fell by 10-15% after approximately 30 minutes, and continued to steadily decline for the remainder of the watch. Eventually he labeled this pattern of experiencing decay in signal dictation over time "vigilance decrement" (Davies & Parasuraman 1982; Helton & Warm 2008; Warm & Parasuraman, 2008).

As vigilance performance is an essential component in many safety-critical occupations, the vigilance decrement can lead to compromised public and employee security (Nickerson, 1992; Williamson et al., 2011). It plays a critical role in military surveillance (e.g., unmanned vehicles, detection tasks to thwart terrorist activity), medical monitoring (e.g., intraoperative and perioperative monitoring of patient vital signs), navigation (air traffic control, cockpit monitoring, seaboard navigation, long-distance driving), and homeland security (e.g., airport baggage screening, border and port security), among other domains. A number of accidents, many resulting in loss of life, can be traced back to human operators committing vigilance failures in these contexts (Hawley, 2006; Molloy & Parasuraman, 1996). In light of the significant consequences of vigilance failures, ergonomic and human factors researchers have devoted considerable attention to the topic.

Vigilance Decrement

The goal of detection is what makes vigilance tasks unique from regular attention-based tasks. As discussed above, evidence in vigilance research points toward the finding that detection performance tends to deteriorate over time, a consequence referred to as "vigilance decrement" (Warm & Parasuraman, 2008). It occurs in both experienced and novice observers as well as in both the lab and the field (Warm, Matthews, & Finomore, 2008). Estimates of when decrement begins vary. In general, the decline occurs in the initial 15 to 30 minutes of attention. When task demands are particularly taxing, decline in detection can occur rapidly, in a matter of minutes (Teichner, 1974; Nuechterlein, Parasuraman, & Jiang, 1983).

Moreover, this assumes one is "fresh" prior to starting a vigilance task. Individuals are likely to experience decrement more quickly or more severely when they enter the watch-keeping session in a tired or stressed state. Brain imaging studies (e.g., Lim, Wu, Wang, Detre, Dinges, & Rao, 2010) have demonstrated that cerebral blood flow prior to the task (i.e., at baseline) can indicate strained neural systems associated with attention, subsequently predicting later decay in performance (e.g., steadily increasing reaction times). This is a pertinent finding for employees in occupations facing cycles of long, variable, or intense work shifts where employees may be especially susceptible to burnout and poor recovery (Demerouti, Bakker, Nachreiner, & Schaufeli, 2001).

Resource Theory vs. Underload Theory

It is central to highlight that two camps of research exist which have debated why the vigilance decrement may occur. On the one side, Robertson and colleagues' underload theory (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) asserts that decrement is caused by observer boredom. Conventional wisdom might lead one to this conclusion as well. That is, because threats or signals are rare, individuals see the task as monotonous, therefore becoming bored or disengaged in between critical moments of detection. As such, they face a higher propensity for committing errors. Following this theory, typical interventions would be designed to lessen task monotony and add task switches to disperse periods of vigilance.

On the other side of the argument, resource theory proponents such as Parasuraman, Helton, Grier, Warm, and many other colleagues (Grier, Warm, Dember, Matthews, Galinsky, & Szalma, 2003; Helton & Russell, 2011; Helton & Warm, 2008; Parasuraman & Davies, 1977; Parasuraman, Warm, & Dember, 1987; Warm et al., 2008) suggest that observers face a significant amount of overload. Proponents of resource theory contend that, although these tasks may be tedious, the information processing demands necessary for maintaining vigilance are quite high. During a vigilance task, observers face an ambiguous context of constantly differentiating rare signals (e.g., enemy submarine) from ubiquitous non-signals (e.g., natural underwater noise), often for long periods without respite. The ensuing mental demands lead to depletion of one's limited cognitive resources.

Numerous self-report, behavioral, and physiological studies have studied and experimentally compared the above theories. In these studies, observers often report high levels of cognitive load and stress (Warm et al., 2008). Further, experimental studies show that vigilance tasks deplete working memory capacity (Parasuraman, 1979). For example, in a series of studies, Warm, Dember, and Hancock (1996) examined perceived workload due to various vigilance task demands (e.g., signal salience, event rate). In each study, workload scores were high, with mental demand and frustration as the two main subscales most related to vigilance task demands.

Helton and Russell (2012) further compared the two theories by designing a study to compare groups that received content-free cues and task switches with a control group. Content-free cues include unpredictable signals (e.g., audio, visual) in order to redirect attention towards the task and bolster performance. Task switches are momentary breaks from the task at hand to engage in an unrelated task. Under the rationale of underload theory, experimental groups would be predicted to experience a desired respite or diversion from the task at hand and, thus, be able to refocus their attention. Instead, the authors uncovered that all three groups experienced comparably high vigilance decrement as reflected in similar decline in perceptual sensitivity, rise in response latencies, and increased levels of perceived workload and task-unrelated thoughts.

Moreover, a rising research domain in neuroergonomics extends these findings (e.g., Parasuraman, 2011). Lim et al. (2010), for example, conducted a brain imaging study which demonstrated that activation of several brain regions (e.g., anterior cingulate cortex, right prefrontal cortex, thalamus) are associated with depletion of resources in a vigilance context. Further, vigilance decrement was linked to a decline in cerebral blood flow (CBF) in the frontoparietal attention network. In particular, decreased CBF to the thalamus and the middle frontal gyrus were significant predictors of performance decline. Hitchcock et al. (2003) leveraged an air traffic control task to study metabolic outcomes, also finding that higher vigilance demand is associated with decreased CBF in the right hemisphere of the brain. Thus, CBF appears to be a strong metabolic indicator of the consumption of one's limited information processing resources.

This research points toward the finding of what Lim et al. (2010) refer to as a "physiological ceiling" associated with vigilance performance. Evidence also indicates there is sometimes little association between self-reported mental fatigue and physiological measures linked to performance decline. That is, while individuals may state that they "feel fine," corresponding physiological measures may suggest otherwise. This finding is especially important in light of jobs (e.g., medical monitoring or long-distance driving) in which subjective and objective measures of alertness and fatigue tend to diverge (Balkin, Horrey, Graeber, Czeisler, Dinges, 2011).

To this point, I have explained studies supporting the viewpoint that vigilance tasks are cognitively taxing. In the same vein, vigilance tasks have also been shown to be quite stressful. For example, some studies have found that vigilance sparks heightened adrenaline and noradrenaline levels (e.g., Frankenhaeuser, Nordheden, Myrsten, & Post, 1971), hormones and neurotransmitters tied to stress. In another study, O'Hanlon (1965) saw a rise in noradrenaline levels when examining subjects in a resting period between vigilance trials, waiting for a subsequent trial to begin. It would seem that even the expectation of engaging in a vigilance task may engender stress.

Szalma (2011) also investigated the interplay between task characteristics and self-reported stress, predicting that signal salience (ease of detecting a signal) would predict stress levels. Interestingly, he instead found that subjective stress increased regardless of signal salience, concluding that there may be a "hidden cost" to vigilance contexts which may be difficult to influence by only manipulating task characteristics. A number of observer reactions more inherent to vigilance tasks, such as a lack of ability to influence task demands and a perception that demands are threatening rather than challenging, contribute to such stress-related outcomes. Further, the demands placed on individuals during vigilance tasks produce anxiety (e.g., Thiffault & Bergeron, 2003). A key characteristic of anxiety is an expectation of an "indefinite threat, and the consequent uncertainty and wait" (Miceli & Castelfranchi, 2005), a common experience in signal detection (Helton et al., 2008) as one searches for potential threats. Shaw et al. (2010) predicted that vigilance performance would influence stress outcomes, but found that stress may remain high independent of level of performance. Whether one is a strong or poor performer, vigilance seems to be emotionally arduous. Despite variations in both task- (e.g., signal salience) and individual-based (e.g., skill) factors, findings suggest vigilance engenders some degree of stress.

Summary

Converging evidence supports the propositions of resource theory. It has emerged as the currently dominant theory in vigilance research (Helton & Russell, 2011). Errors on vigilance tasks appear to be more a product of cognitive and psychological resource depletion than of boredom or monotony (Helton & Russell, 2011; Greir et al., 2003). In fact, studies indicate that the task switches proposed by some researchers supporting underload theory to renew or recapture interest (e.g., Ariga & Lleres, 2011) can serve to further exhaust resources important for vigilance performance (Ross, Russell, & Helton, 2014). In sum, ample research has demonstrated that individuals find long-duration vigilance tasks to be both cognitively debilitating and stressful (e.g., Szalma et al., 2004; Warm, 1993). Figure 1 depicts the expected relationships. Note that I will be examining Block 2 stress, mental demand, and vigilance performance, controlling for baseline levels in Block 1. Consistent with the above findings, it is hypothesized that:

Hypothesis 1: Stress is negatively associated with vigilance performance.

Hypothesis 2: Mental demand is negatively associated with vigilance performance.

.

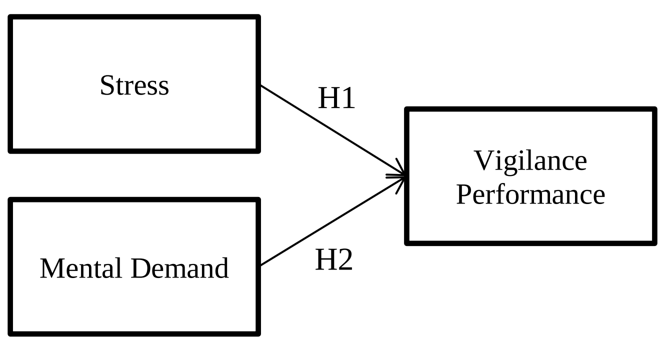


Figure 1. Hypotheses 1 and 2.

Below I will discuss various task demands known to influence vigilance decrement. Tasks may include various levels of complexity and ambiguity. For example, signals can range on a spectrum from high to low salience and frequency. Further, tasks may include numerous signals which require one to successively hold information in working memory. Moreover, depending on the task and person, one's reliance on automatic vs. controlled processing varies, ultimately impacting vigilance.

Signal Detection Theory and Vigilance Tasks

First, vigilance performance is often described from a signal detection framework. When performing a vigilance task, individuals monitor for the presence of a particular signal typically amid some degree of noise (e.g., monitoring for threatening terrorist chatter among harmless communications). Meta-analytic evidence suggests that when discrimination demands increase (i.e., more noise exists and signals are weaker), there is a greater propensity for vigilance decrement to occur. Signal salience is characterized as the overall likelihood of detecting a critical signal from noise. Stated more simply, signal salience refers to the ease of signal detection. It is one of the largest predictors of vigilance decrement (See, Howe, Warm, & Dember, 1995). Evidence reveals low signal salience leads to a quicker plummeting of one's limited pool of resources and, thus, greater vigilance decrement (Helton, Warm, Mathews, Corcoran, & Dember, 2002).

Understanding signal detection theory (SDT) involves a discussion of several key terms and statistics (Abdi, 2007). First, when one accurately identifies a signal amid noise, this is called a *hit*. *Hit rate* refers to one's propensity to correctly classify a signal when it is present. Alternatively, when one misidentifies noise, confusing it for a signal, this is termed a *false-alarm*. Accordingly, the *false-alarm rate* is one's propensity to identify a signal when it is absent.

The hit and false-alarm rates relate to two characteristics: response bias and sensitivity. Though both have implications for performance, the two are independent from one another. Response bias refers to one's overall *likelihood* of responding that a signal is present or not present. Some individuals will require less evidence before stating that a signal is present. For example, one may be especially cautious in scenarios where a miss has devastating consequences (e.g., detecting an enemy plane), and thus, more liberally label a signal as present and risk a false-alarm rather than a miss. Sensitivity, on the other hand, refers to one's *ability* to differentiate signals from non-signals. That is, how skilled is one at detecting critical targets? Further, sensitivity is impacted by situational factors such as signal salience. When signal salience is low, more skill is necessary.

Task Demands and Vigilance Decrement

The response bias and sensitivity distinction is an important one (Stanislaw & Todorov, 1999) in practice and analysis. First, and less related to this study, the distinction has implications for task design. For example, numerous efforts have been made to improve technology in order to increase signal salience, thus making threats more easily identifiable. In addition, design considerations have been pursued in order to direct individuals to err on the side of the less-costly mistake (e.g., bias towards false alarms rather than misses). Additionally, to be successful, individuals must calibrate the correct level by which they should lean toward a "yes" vs. "no" (response bias) as well as develop their skill and aptitude for correctly identifying a target (sensitivity).

Vigilance decrement is also impacted by the degree to which one must differentiate targets from non-targets and subsequently hold this information in working memory (Davies and Parasuraman 1982; Parasuraman, 1979; Parasuraman, Warm, & Dember, 1987; Warm and Dember, 1998; Warm et al. 2008b). In Parasuraman's (1979) study, he found that decrement was more severe when stimuli were presented quickly in "successive-discrimination" tasks as this is particularly taxing on one's limited attentional resources and requires one to lean on his or her working memory. As an example, consider the job of a pilot or anesthesiologist challenged with concurrent tasks in which they must weigh previous decisions in light of new information. Failure to recall a prior decision could result in severe consequences. On the other hand, if the stimuli (e.g., threats vs. non-threats) are presented at the same time in "simultaneous discrimination" tasks, individuals' ability to remain vigilant remained relatively stable over time. Thus, when individuals did not have to remember a target, but simply discern the target from the non-target, they experienced less vigilance decrement.

Further, the above studies found that a number of factors impact the severity of decrement in a successive task. For example, the frequency with which critical signals surface (i.e., event rate) is a key element. It is associated with a much starker depletion of information processing resources in a successive as opposed to a simultaneous task. With a very low event rate, decrement associated with the demands of a successive task is less likely to occur. Other factors tied to a similar outcome include multitasking demands as well as ambiguity and irregularity around when and where the critical events will happen. The latter, location of signals, is connected to a greater reliance on spatial working memory which has been shown to be especially demanding on one's attention (Caggiano & Parasuraman, 2004).

Severity of vigilance decrement can also be influenced by the degree to which one must tap into automatic as opposed to controlled processing. Fisk and Schneider (1981) discuss how we can study vigilance decrements from this two-process theory of information processing. They assert that the type of processing and amount of practice are important factors in decrement. Decrement tends to occur when one must employ significant controlled processing resources. "Maximum vigilance decrements" happen when observers need to repetitively rely on their more effortful, controlled processing. Some of the demands described above are likely to increase one's tendency to rely on effortful processing. Finding ways to increase reliance on more automatic processing should help alleviate some vigilance decrement.

Moreover, vigilance decrement is impacted by the emotional valence of critical stimuli. In general, emotional as opposed to neutral stimuli are more likely to be identified (e.g., Keil & Ihssen, 2004). However, in a vigilance context, performance can be negatively affected by targets which elicit negative task-unrelated reactions (Helton & Russell, 2011). In Helton et al.'s (2011) study, negative picture stimuli were detected less commonly than neutral stimuli. The rationale is that observers ruminate on these stimuli after they are presented, thus reducing one's supply of resources and energy necessary for maintaining performance. This is an important finding for occupations which encounter emotional stimuli (e.g., combat, medicine, or disaster relief). In these types of contexts, the authors argue that observers may need additional support and training to address stress and emotional demands.

Reducing the Vigilance Decrement

In order to combat the vigilance decrement, much of the research to date focuses on job and task design. For example, advanced warning systems to provide feedback and alert observers of upcoming perilous signals have been examined (e.g., Hitchcock et al., 2003) Advancements continue to be made in this area as the prevalence of automation in human-machine systems has accelerated (Parasuraman & Riley, 1997). Further, researchers have examined the effectiveness of leveraging not only visual displays, but when feasible, audio alerts (e.g., McIntyre, 1985). Additionally, researchers have investigated ways to influence the signal-to-noise ratio, an important factor in vigilance performance – the more noise, the more intense the vigilance decrement (Warm & Jerison, 1984).

While these advancements in system design have proven fruitful, they do not resolve the inherent taxing nature of vigilance tasks. Though task design can reduce some of the demands placed on observers, the goal of these tasks is still the same: to monitor for dangerous, often life-threatening, but infrequent signals. Task design can be of assistance but will not wholly eliminate these demands. For example, although audio signals may assist an anesthesiologist or an air traffic controller when monitoring for critical signals, the task itself and many of its demands remain. Interventions aimed at not only the task, but also the *individual,* to promote his or her ability to manage and cope with demands are important. Several avenues have been examined in vigilance research thus far. I will review these before turning to mindfulness.

Individual-Based Interventions

Caffeine is perhaps the most studied and relied upon approach for enhancing vigilance performance (e.g., Beaumont et al., 2001; Fagan, Swift, & Tiplady; Frewer & Lader, 1991; Lane & Phillips-Bute, 1998; Lieberman, Tharion, Shukitt-Hale, Speckman, & Tulley, 2002; Temple et al., 2000). For example, in a study examining sleep-deprived U.S. Navy Seals during a critical training period, researchers studied various quantities of caffeine intake and found an optimal amount, 200-300 mg, at which caffeine alleviated various stressors due to sleep deprivation and improved cognitive performance in a vigilance task (Lieberman et al., 2002). A study by Temple et al. (2000) found similar effects related to augmentation of performance but did not replicate findings that caffeine reduced task-related stress. Though caffeine and other stimulants appear to elicit some degree of positive change, given the habit-forming risk, the transient nature of their benefits, and the mixed findings of their impact on stress, providing other means for alleviating demands in these contexts is important.

Unsurprisingly, sleep is imperative to vigilance performance. Beatty, Ahern, and Katz (1977) studied anesthesiologists in a surgical simulation in both a rested state as well as a mildly sleep deprived state, finding that sleep deprivation negatively influenced their ability to effectively monitor patient functions. Numerous other studies have highlighted the connection between lack of sleep and vigilance decrement (e.g., Kribbs, & Dinges, 1994). Although sleep can refresh one’s resources in between workdays, the trouble exists that resting during the workday is typically not a viable option.

As a consequence, some employees are prone to experiencing extreme fatigue or even falling asleep on the job. The work schedules of air traffic controllers, for example, are known to cause significant fatigue. In a recent study (U.S. Department of

Transportation, 2012), the Federal Aviation Administration partnered with NASA to examine air traffic controller fatigue. They surveyed 3,268 controllers, representing 19% of certified controllers in the United States. 70% of controllers on the midnight shift reported that they had caught themselves almost falling asleep during a shift, and 18% of individuals noted that they had made a significant error in the prior year (e.g., directing planes uncomfortably close together). Over half of these individuals attributed their error to fatigue. This is unsurprising given the study uncovered that controllers only acquired 5.80 hours of sleep and 3.25 hours of sleep on average prior to a day or night shift, respectively, due to irregular sleep patterns as a result of shift work. Given the consequences of controller error, these findings are alarming. Over the past couple of years, the FAA has made key changes to controller shifts to promote recuperation.

Occupational exceptions allowing sleep on the job include certain jobs requiring prolonged shifts (e.g., medical residents) in which, at times, individuals may be allowed short rest periods. Although there is no proxy for sleep, it is important to explore alternative interventions which reduce decrement even in the face of sleep deprivation given its unfortunate reality in many occupations and for many individuals. Approximately 30% of adults experience one or more symptoms of insomnia (Roth, 2007), and employees in many occupations, in addition to the above, regularly encounter sleep disturbances.

Breaks are also a method known for replenishing emotional and cognitive resources (Baumeister et al., 1998). Work breaks can entail a number of activities (e.g., time away from the office, time for rest; Demerouti, Bakker, Sonnentag, & Fullagar, 2012). Ross, Russell, and Helton (2014) provided a series of short rest breaks, finding that the first break was able to overturn the vigilance decrement from the previous trial. However, vigilance decrement seems to be connected to a linear growth in workload as a vigil progresses. As a result, the study did not find that the second break allowed for sufficient recovery, positing that perhaps the break was not long enough to parallel the accumulated length of the task up to this point. Though breaks are advantageous, workers in some occupations are only allotted short breaks which may not offer the necessary depth of recovery following longer-term vigils common in many jobs.

More research is also needed to examine ways to further augment the use of breaks. The break's effectiveness may be moderated by the type of activity one performs while on break. For example, not surprisingly, one study found that carrying out certain tasks such as prepping for a meeting were related to negative emotions (Trougakos et al., 2008). Additionally, Trougakos et al. (2011) found evidence suggesting that even certain social activities during lunch breaks are associated with greater levels of fatigue during the day. Specifically related to vigilance, a study by Helton and Russell (2012) examined task switching (a break from the vigilance task to engage in a different activity) and, in line with resource theory, found that task switches are related to increased informational processing. Task switches increased informational processing demands and thus, elicited a decrease in subsequent performance as seen in lower perceptual sensitivity and higher response times. As such, a break which entails additional strain on cognitive resources could potentially do more harm than good. One study found that employees who took part in more recovery activities, like relaxing or sleeping, during breaks at work benefited from more positive emotions and less negative emotions throughout the breaks (Trougakos et al., 2008).

Provision of practice trials and training is also a viable means for promoting performance in vigilance contexts (e.g., McCarley, Kramer, Wickens, Vidoni, & Boot, 2004). In many occupations, highly trained operators are responsible for detecting threats. Thus, some posit that the use of untrained observers and a lack of practice is one of the major reasons vigilance decrement occurs in studies (Mackie, 1987). Parasuraman and Giambra (1991) addressed this gap in the research and put observers through extensive training. While they found that in-depth training can alleviate some of the vigilance decrement, it does not fully eradicate it, particularly in older subjects. Further, the authors suggest that even highly trained observers are likely to see some decrement in tasks that are especially lengthy (e.g., over 1 hour).

In occupations in which signals occur infrequently, false or task-unrelated signals such as noise are sometimes employed with the goal of keeping observers vigilant. Some posit that these signals may refocus observer's attention and increase performance. However, meta-analytic evidence from Szalma and Hancock (2010) found that unpredictable periodic exposure to task-unrelated signals can actually be more encumbering than are more frequent or prolonged signals as they compete for limited cognitive resources. The authors discuss that, "Such a finding is in contrast to the argument that short-duration exposure may facilitate performance because of the transient arousing effects of noise that can temporarily increase information-processing resources" (p. 697). This finding is corroborated by other work (e.g., Helton, 2008; Cox-Fuenzalida, Swickert, & Hittner, 2004) which suggests erratic environmental changes and demands are one of the most considerable triggers of stress in a vigilance task. In lab studies, signals tend to be more predictable and information processing demands more consistent than what is often experienced by employees in the field. Occupations such as air traffic control or medical monitoring tend to face more sudden and irregular shifts in demand, thus likely exacerbating the demand-stress relationship in these contexts.

Although many of the previously studied interventions to circumvent the vigilance decrement have proven to be fruitful, as highlighted above, none fully eliminate this effect and some may even intensify it. Further, though vigilance studies target ways to relieve information processing demands, far fewer studies have investigated methods to reduce stress attributed to demands in these contexts. As Szalma (2011) posited, researchers and practitioners may be limited in their ability to reduce stress in a vigilance context merely by altering task qualities. As several authors (e.g., Finomore, Matthews, Shaw, Warm, & 2009; Shaw et al., 2010) have suggested, research focused on individual characteristics and behaviors would be advantageous. To further explore this gap, I will discuss a new avenue for research, *mindfulness*, and delineate mechanisms by which it is proposed to operate.

Mindfulness

The practice of *mindfulness* has consistently been shown to be useful in non-vigilance applications. It has received a great deal of attention over the last three decades. In fact, there has been an apparent explosion of research and application of the practice throughout this time. Though it derived its roots from Buddhism, mindfulness since evolved after being ignited by the work of Jon Kabat-Zinn at the University of Massachusetts Medical School in the 1970s and then taken hold in Western psychology. The secular application of mindfulness is, at its core, simply the practice of being in the present moment, while remaining open to and accepting of one's experiences and thoughts as they arise (Brown & Ryan, 2003). Though mindfulness is sometimes equated with meditation, the two are not completely synonymous. Mindfulness entails awareness of one's moment-to-moment experiences, while meditation is a practice often used to develop one's state and ability of being mindful (Kabat-Zinn, 2005).

Kabat-Zinn (2003) brings the most commonly cited definition of mindfulness. He defines it as "paying attention on purpose, in the present moment, and nonjudgmentally." Most adhere to Bishop et al.'s (2004) model of mindfulness which proposes that mindfulness contains two key components, represented in the above definition. The first component is self-regulation of attention. This is defined as a focus on one's immediate, present thoughts and experiences. This is not a preoccupation or maladaptive focus, but rather a healthy awareness of one's thoughts and experiences. In other words, mindfulness cultivates a healthy metacognition (Zeidan, Johnson, Diamond, David, & Goolkasian, 2010) as well as wakefulness to one's environment. In the literature, it is frequently described as being "fully present and alive in the moment" (Bishop et al., 2004; p. 232).

The second component in Bishop's model entails possessing a particular orientation towards one's experiences. It involves an open, accepting, and receptive attitude toward one's moment-to-moment experiences and thoughts. It can also be described as a "stance of acceptance" or "process of openly relating to experience." Bishop et al. (2004) suggest this is related to reduced avoidance (e.g., more adaptive coping), increased affect tolerance (e.g., seeing thoughts and feelings as fleeting), and more complex cognitive capacity (e.g., ability to discern and assimilate mental and emotional experiences). Studies have also shown that these components of mindfulness replenish attentional resources, improve emotional regulation (Nielsen & Kaszniak, 2006), and decrease stress (Carlson, Speca, Faris, & Patel, 2007), among other beneficial outcomes.

A number of organizations have discovered mindfulness' effectiveness and have begun to leverage the practice. To name a few, Google, General Mills, Bank of America, Mayo Clinic, Goldman Sachs Group, the United States military and graduate schools such as Harvard Business School each offer mindfulness training (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Kelly, 2012, Gelles, 2012; Chen, 2015; Hyland et al., 2015). Despite the increased attention of mindfulness in organizational settings, until recently, the actual practice of mindfulness at work perhaps out-accelerated the research behind it. Strides are currently being taken to take a more empirically driven approach (see Hyland et al., 2015 for an extensive discussion). I will first discuss a few of the recent findings before turning to mindfulness in a vigilance context.

Hülsheger and colleagues have published a couple of studies within the past few years in the *Journal of Applied Psychology* which examine the effects of mindfulness in the workplace. Hülsheger, Alberts, Feinholdt, and Lang (2013) observed that those receiving a mindfulness intervention reported lower emotional exhaustion and higher job satisfaction compared to those in a control group. Further, Hülsheger et al. (2014) carried out a daily diary study which found that mindfulness experienced throughout the workday was related to sleep quality that night and that this relationship was mediated by psychological detachment from work activities. These researchers have called for more research to examine mindfulness as a recovery activity at work.

A number of other positive effects have been found in the work realm as well. For example, Allen and Kiburz (2012) found that trait mindfulness is related to work-family balance, a relationship that was mediated by sleep quality and vitality. Further, Narayanan and Moynihan (2006) found that mindfulness helped decrease burnout in a call center setting. Mindfulness training has also been found to reduce stress and foster well-being in human services professionals, a profession especially prone to burnout and feelings of inability to cope with work demands (Poulin, Corey, Soloway, & Karayolas, 2008). Finally, Chu (2010) found that mindfulness is connected to higher levels of emotional intelligence.

Specifically related to safety performance, Zhang and colleagues have started to pave the way in research on the connection between mindfulness and safety performance. In two studies (Zhang, Ding, Li, & Wu, 2013: Zhang & Wu, 2014), the researchers found a positive relationship between trait mindfulness and subjective ratings of safety in a real-world context, specifically, among nuclear power plant employees. The explanatory power was in employees' ability to bring present awareness to their tasks. However, this effect was most relevant for more complex tasks and for more intelligent employees. The authors assert that for more rudimentary, less complex tasks, where efficiency is valued more than accuracy, mindfulness may actually be more harmful than helpful. Beyond this work, in their seminal review of mindfulness' influence in organizations, Good et al. (2016) further highlight the importance of examining mindfulness and safety performance in future research.

Given the benefits of mindfulness in both work and non-work domains, mindfulness may also provide benefits for performance on safety-critical vigilance tasks.

The overarching process can be examined from the framework of the Job Demand-Resources (JD-R; Demerouti et al., 2001) model. The JD-R model suggests that job strain occurs when there is an imbalance between the demands employees encounter (e.g., time pressure, anxiety) and perceived availability of resources to manage such demands (e.g., cognitive capacity, equipment). When faced with significant demands, individuals tend to engage in “performance protection,” which can manifest in the form of physiological, physical, or mental exertion. However, personal resources are limited, and this added energy comes with a psychological price, including potential outcomes such as attentional selectivity, risky behavior, or high levels of fatigue (Bakker & Demerouti, 2007). In a vigilance context, these outcomes can lead to error in judgement and unsafe decisions.

Through this process, I suggest that the positive effects of mindfulness on vigilance performance will be mediated by two intermediary processes: stress and mental demand. It is expected that, as mindfulness promotes present and receptive attention, it will better equip individuals to handle vigilance demands by protecting and replenishing precious resources, ultimately safeguarding the need to over-rely on performance protection methods which can engender stress and deplete cognitive resources. First, I will discuss the proposed relationship between mindfulness and stress. Then, I will turn to the relationship between mindfulness and cognitive resources. Figure 2 depicts the expected relationships.

Mindfulness and Stress

As explained above, numerous psychological and physiological studies indicate vigilance contexts are particularly stressful because they entail extensive reliance on one's limited pool of resources. Moreover, they are sometimes accompanied by negative emotional stimuli (Grier et al., 2003; Hancock & Warm, 1989; Szalma, Warm, Matthews, Dember, Wiler, & Meier, 2004; Warm et al., 2008). To combat these effects, I propose mindfulness is a valuable intervention to explore.

Evidence indicates that mindfulness is associated with improving a number of indicators of well-being such as stress, fatigue, emotional exhaustion, negative affect, and anxiety (Brown & Ryan, 2003; Hulsheger et al., 2014; Tang et al., 2007; Zeidan et al., 2010). By far the most commonly studied outcome of mindfulness, though, is stress. To narrow the focus of my study, I chose this particular well-being outcome of interest as it already exhibits extensive theoretical support.

Neuroimaging studies indicate that mindfulness is associated with activation in stress-related brain regions and, over the long term, with structural changes in the brain (e.g., Hölzel et al., 2009, 2011; Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004). For instance, Hölzel et al. (2009) found evidence of reduced amygdala gray matter density following mindfulness-based stress reduction. In another study, Hölzel et al. (2011) found increased gray matter concentration in the hippocampus, an area known for its synaptic plasticity and neuron generation as well as its role in emotional regulation. The human brain demonstrates a remarkable ability to structurally recover, and mindfulness appears to be one such method for circumventing or even reversing the long-term effects of stress on key areas of the brain.

Other studies have demonstrated the physiological benefits of mindfulness as well. For example, Davidson et al. (2003) compared those in a mindfulness meditation group to a control group; the former experienced left-sided anterior activation, a brain region linked with levels of positive affect. In this same study, the participants received the influenza vaccine at the end of the intervention. Those in the mindfulness group encountered significant rises in levels of antibodies compared to the control group, suggesting that immune system functioning was higher following mindfulness. These discoveries are in alignment with previous brain imaging work demonstrating mindfulness is related to reduced stress and more favorable responses to threatening situations (Brown, Ryan, Creswell, & Niemiec, 2008). Brain imaging offers an objective source of data connecting mindfulness to decreased stress.

Having established that mindfulness is often associated with decreased stress, researchers have delved into the processes behind *why* mindfulness does so. Evidence underlying such mechanisms is somewhat sparse, albeit growing. The most commonly studied theory of occupational stress, the socio-cognitive or transactional model (Lazarus & Folkman, 1984), sheds light on these mechanisms. This model emphasizes the interplay between the person and environment in which two key processes appear to be at play: primary appraisal and secondary appraisal (i.e., coping). Upon experiencing a potential stressor (e.g., stressful job conditions), primary appraisal occurs in which an individual judges whether the stressor is threatening. If it is, secondary appraisal occurs in which an individual assesses whether he/she has the resources to cope with the stressor. If an individual deems that his/her personal resources are ill-equipped to manage environmental demands, strain is likely to occur (i.e., adverse responses to stressors).

Developing research suggests mindfulness may be better understood by examining the above framework (Weinstein et al., 2009). First, in primary appraisal, mindfulness fosters a less self-protective stance toward one’s experiences. It has been shown to promote an openness to confront or even embrace seemingly intimidating or difficult situations (e.g., vigilance tasks). In a mindful state, one's appraisal of such experiences is likely more positive and receptive. Second, through secondary appraisal, mindfulness may promote enhanced coping strategies to bolster one's perceived resources to meet job demands. Below I further detail these two mechanisms.

Mindfulness and Primary Appraisal. As Marcus Aurelius once remarked, "If you are distressed by anything external, the pain is not due to the thing itself, but to your estimate of it; and this you have the power to revoke at any moment (C. 169/1957, VIII:47). Evidence indicates that those who practice mindfulness are less likely to perceive events as stressful (Weinstein et al., 2009). Stressor appraisals are simply cognitive processes one uses to judge a particular situation. Often, when individuals encounter an experience, they adjust its affective meaning by either modifying their impression of the event or shifting their understanding of their ability to manage the demands which may ensue. One might positively appraise their experience as good or perhaps even challenging. On the other hand, one can also negatively appraise their experience as negative, threatening, or unsafe.

A fundamental characteristic of being mindful is that individuals are not only anchored in the present moment but also bring an open, accepting, and less emotionally reactive attitude to their appraisal of the environment. In a more mindful state, one will employ a more open mindset when facing challenging situations, increasing the likelihood that one experiences more benign cognitive evaluations of stressors and less subsequent strain (Weinstein et al., 2009). In a series of studies, Weinstein et al. (2009) found that those higher in trait mindfulness as well as those who had received a mindfulness intervention tended to have more favorable cognitive evaluations of stressors, viewing them as less threatening.

Because vigilance tasks are stressful and often time-intensive, this finding is important. When encountering vigilance demands, individuals will likely stay more present and openly receptive. In particular, when one engages in long-duration stress-inducing tasks, mindfulness can offer a protective effect. For example, Steffen and Larson (2014) examined physiological measures in a multi-phase laboratory stressor (timed math test), finding that the mindfulness experimental group exhibited less physiological distress whereas the control group exhibited more distress over the course of the experiment. Further, when facing especially threatening stimuli (e.g., viewing unsettling pictures; Arch & Craske, 2006), evidence indicates that even one-time mindfulness interventions are associated with more adaptive appraisal, assuaging a stress reaction before it fully takes effect.

Mindfulness and Secondary Appraisal. Second, upon facing a stress reaction, those in more mindful states are more likely to employ adaptive coping mechanisms to overcome strain (Weinstein et al., 2009). Stress research has concentrated significantly on coping strategies defined as the cognitions and behaviors employed to handle situational demands perceived to be stressful (Folkman & Moskowitz, 2004). These strategies are diverse and can range from adaptive, approach-based (e.g., recovery, problem-solving, spiritual, social support) to maladaptive, avoidant-based (e.g., rumination, withdrawal, catastrophizing, denial, substance abuse).

Approach coping is enacted when one faces stressful events by actively facing them in a healthy and productive way. For example, one might cope by treating their stressor as a problem to overcome. Approach coping often entails reappraisal which is associated with a more adaptive response to acute stressors (Jamieson, Mendes & Nock, 2013) such as a vigilance task. On the other hand, *avoidant coping* is a less adaptive, more defensive alternative (Roth & Cohen, 1986). It can include disengagement (mental or behavioral) as well as denial (Carver & Connor-Smith, 2010). In a vigilance context, avoidant coping has been linked to increased vigilance decrement as it is likely associated with less task focus (Shaw et al., 2010). Relevant to this study, rumination and catastrophizing are two coping styles that may hurt performance as these cognitions inherently compromise one's moment-to-moment attention.

Mindfulness tends to spur a more adaptive style of coping in which individuals are better equipped to approach stressful events they might encounter. In particular, mindfulness subserves richer attentional states and more objective evaluation of one's internal processes in-the-moment. In addition to promoting better awareness, mindfulness promotes a healthy detachment and accepting orientation toward one's states. Researchers have posited that a lack of detachment from work activities and rumination on one's work experiences can lead to a "mental continuation of work stressor" (Querstret & Cropley, 2012; Sonnentag, Binnewies, & Mojza, 2008). After engaging in a stress-inducing vigilance task, individuals may be inclined to ruminate on their performance or their feelings or to catastrophize about an upcoming work shift or trial. This avoidant coping may compromise recovery and potentially leave one vulnerable to missing critical signals in their next vigil. Mindfulness, on the other hand, cultivates a healthy, "intimate detachment" (Peters, 2004) and directs attention to the present.

Additionally, mindfulness, compared to other interventions, is associated with both enhanced self-awareness and self-compassion (Brown & Ryan, 2003; Hollis-Walker & Colosimo, 2011). As Brown and Ryan (2003) describe, “Mindfulness captures a quality of consciousness that is characterized by clarity and vividness of current experience and functioning and thus stands in contrast to the mindless, less “awake” states of habitual or automatic functioning that may be chronic for many individuals” (p. 823). Not only is one more self-aware in a mindful state, but mindfulness also promotes self-compassion. That is, though one is aware of internal states, he/she is also openly receptive of them. These findings offer important implications for individuals in occupations (e.g., air traffic controllers) experiencing heavy vigilance demand, where higher stress, emotionally taxing stimuli, and burnout are common.

Summary. In summary, mindfulness allows one to more effectively combat against stress through more effective coping mechanisms. Mindfulness as an intervention is likely a valuable means of protecting against the onset of stress in a vigilance context. In many vigilance contexts, heavy demands are a tough but inherent reality. While improving organizational resources and reducing task demands is important, it is also critical that vigilance research and practice examine methods for helping employees better cope with such demands. Mindfulness is predicted to boost the resources employees have available to do just this.

Given these mechanisms, it is predicted that stress will mediate the relationship between mindfulness and vigilance performance. As described above, mindfulness is likely to cultivate more adaptive appraisals of and responses to the vigilance task, reducing the onset and continuation of stress. By grounding individuals in the moment and away from stress-related ruminations and mind wandering, mindfulness promotes increased task focus, which Shaw et al. (2010) describes as an important coping strategy in a vigilance context. Given that vigilance tasks necessitate continuous evaluation of potential threats, one may speculate that an avoidant coping strategy is not uncommon in such contexts. It is predicted that mindfulness will circumvent this type of appraisal. In turn, stress is less likely to deplete resources and compromise future performance. Thus, it is hypothesized that:

Hypothesis 3: Participants who experience a mindfulness intervention will experience less stress than participants in a control group.

Hypothesis 4: Stress mediates the association between mindfulness and vigilance performance.

Mindfulness and Mental Demand

The second way mindfulness is posited to influence vigilance performance is by bolstering cognitive outcomes. As delineated above, numerous studies suggest that vigilance tasks are tedious and inflict considerable mental demand on individuals (Hitchcock, Dember, Warm, Moroney, & See, 1999; Temple et al., 2000; Warm, Dember, & Hancock, 1996). Studies have examined breaks as a method for recovering mental capacity. However, as previously mentioned, break content moderates its effectiveness (e.g., Helton & Russell, 2012). In the present study, I suggest that mindfulness may be an effective recovery activity that individuals can perform during breaks from vigilance tasks.

A number of studies have demonstrated the positive effect mindfulness has on attention and information processing (e.g., Wells, 2002). During a vigilance task, one must sustain long periods of unremitting judgment characterized by complexity and unpredictability (Davies & Parasuraman, 1982). To combat the depletion of limited cognitive resources, I propose that mindfulness is likely to improve vigilance performance by allowing one to free and recover mental resources necessary for detecting signals and sustaining levels of attention.

Further, in especially demanding vigilance tasks, the propensity for one to ruminate on previous experiences or anticipate upcoming demands may be high. For example, air traffic controllers might become overwhelmed by ruminating on an accident in the news or by worrying about a potential increase in volume or imminent poor weather. While some degree of healthy concern is important, becoming engulfed in these thoughts is unproductive and can compromise performance. It is expected that mindfulness will circumvent such thought tendencies as, again, the goal of mindfulness is to simply observe one's environment, bringing focus to the present and away from past and future concerns (Kabat-Zinn, 1990). Mindfulness is likely to encourage an enriched awareness of the task at hand through less task switching and more sustained attention (Bishop et al., 2004).

These outcomes are especially important when one has to discriminate between targets and non-targets in successive-discrimination vigilance tasks (e.g., Davies & Parasuraman 1982). Evidence suggests decrement is stronger in these types of tasks as one has to heavily leverage his or her working memory to weigh previous decisions. Given mental resources are especially taxed in these tasks, holding task-unrelated information in memory from trial to trial causes performance to suffer. Because mindfulness directs one's awareness to the "here and now," it likely alleviates some of this effect. That is, it lessens individuals' automatic tendencies to reflect on past experiences and experience task irrelevant thoughts (Shapiro, Brown, & Biegel, 2007; Jain et al., 2007), thus releasing needed cognitive resources.

Mindfulness has been shown to increase the attentional resources necessary for sound information processing as it increases one's overall working memory capacity. For example, Jensen et al. (2012) compared incentivized mindfulness-based stress reduction to both incentivized active and inactive control groups. The researchers found that only the mindfulness group experienced improved working memory capacity. They concluded that increased effort was not likely the reason for the outcome of the mindfulness-based stress reduction group since they were each equally incentivized. Further, a study by van den Hurk, Janssen, Giommi, Barendregt, and Gielen (2010) found that mindfulness is not only related to improved top-down processing, but also associated with changes in bottom-up processing. It is predicted that this freeing of resources will assist in repletion of resources and bolster observers' sensitivity, their ability to detect a target from a non-target.

A core component of mindfulness is that it improves sustained attention. A commonly used practice leveraged in mindfulness interventions is awareness of the breath. Mindful breathing, as it is often labeled, entails a focus on the ingoing and outgoing breath. The ultimate goal is to cultivate an ability to attend to breath and to avoid districting thoughts. Practice helps individuals focus over longer periods of time, experiencing less mind wandering and distraction over time. Other similar interventions such as mindful eating or body scanning similarly promote sustained attention. A number of studies have highlighted this finding (e.g., Valentine & Sweet, 1999). Further, one need not be very experienced in mindfulness to benefit. A key study by Mrazek, Smallwood, and Schooler (2012) found that simply 8 minutes of mindfulness breathing decreased encounters of mind wandering in comparison to two active control groups (i.e., relaxation, reading). A study by Chiesa, Calati, and Serretti (2011) further suggests mindfulness is related to improved allocation of attentional resources Given that one's ability to sustain attention is critical to vigilance performance, it is expected that the above benefits will extend to this context.

Helton and Russell (2011) propose that, in a vigilance demand context, "there may be individual differences in regard to susceptibility to task-unrelated thoughts, tendency to ruminate, and cognitive intrusions (Helton & Holmstrom, 2006; Reason, 1993; Reason & Lucas, 1984)." They go on to argue that creating valid and reliable measures may help detect and screen for these individual differences in employee selection for jobs requiring vigilance performance. Further, they propose that training programs may be developed to mitigate the impact of these individual differences. I propose that mindfulness is a fruitful area for research to address their proposition. It is hypothesized that:

Hypothesis 5: Participants who experience a mindfulness intervention will experience less mental demand than participants in a control group.

Hypothesis 6: Mental demand mediates the association of mindfulness with vigilance performance.

Interplay between Well-Being and Cognitive Resources

High amounts of stress further deplete one's limited supply of cognitive resources (Diamond, Fleshner, Ingersoll, & Rose, 1996; Oei, Everaerd, Elzinga, Van Well, &

Bermond, 2006). Promisingly, mindfulness has been shown to be especially effective at increasing working memory capacity in *stressful* situations. For example, Jha, et al. (2010) studied a group of marines prior to deployment. One group was taught mindfulness meditation, and the other group served as a control. The group of marines trained to meditate experienced greater working memory capacity when under pressure compared to those who were not trained. Given that vigilance decrement is even starker under difficult task conditions (See et al., 1995), the finding that mindfulness improves overall levels of working memory is promising. Moreover, the meditation group encountered a protective effect in that their overall working memory capacity increased, whether under stress or not.

Thus, it is proposed that the two overarching mediators in this study (i.e., stress and mental demand) have a collaborative effect such that compromised well-being (e.g., fatigue, stress) is associated with reduced cognitive resources. Such outcomes relevant within a vigilance context include reduced visual tracking speed, (Andreasen, Spliid, Andersen, & Jakobsen, 2009), diminished spatial working memory (Shackman et al., 2006), and less ability to sustain attention (Schwid et al., 2003). It follows that interventions that promote well-being, thus bolstering information processing capacity, are likely to augment vigilance performance (Zeidan et al., 2010). Thus, the final hypothesis follows:

Hypothesis 7: Mental demand mediates the relationship between stress and vigilance performance.

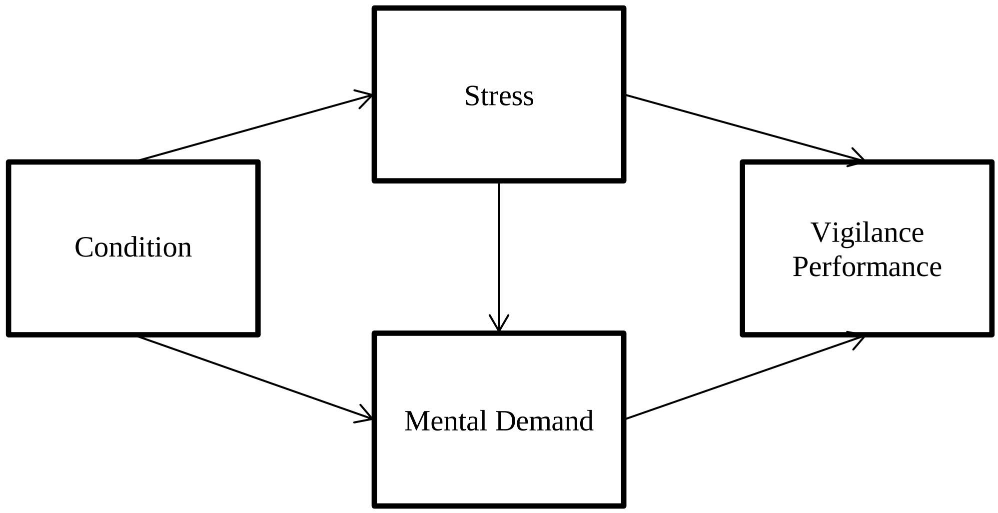


Figure 2. Hypotheses 3-7

Method

Overview

Traditional mindfulness-based interventions require a significant time commitment. For example, a mindfulness-based stress reduction (MBSR) program generally includes once-a-week sessions lasting 2.5 hours and spanning approximately 8-10 weeks. Outside of these sessions, individuals are instructed to spend an extensive amount of time (e.g., 45 minutes) practicing mindfulness each day (Kabat-Zinn, 1982; Grossman, Niemann, Schmidt, & Walach, 2004; Hyland et al., 2015). However, in these studies, generally participants are in environments associated with significant burnout (e.g., health care) or may be experiencing difficult life circumstances (e.g., severe pain, cancer, depression). In fact, MBSR programs were designed with these populations in mind. While these longitudinal, in-depth interventions have shown overwhelmingly positive effects in these contexts, one may question whether the everyday individual or employee is likely to seek out or follow-through on such a time intensive program as it may be difficult to fit such programs into busy calendars or heavy workloads.

In response to these concerns, recent efforts have been directed toward creating more feasible mindfulness interventions for employees. Initial studies have uncovered that more abbreviated interventions as well as one-time mindfulness inductions are associated with positive work and nonwork outcomes (e.g., Arch & Craske, 2006; Fortney, Luchterhand, Zakletskaia, Zgierska, & Rakel, 2013; Grégoire & Lachance, 2014; Hafenbrack et al., 2014; Hülsheger, Feinholdt, & Nübold, 2015; Klatt, Buckworth & Malarkey, 2008; Papies, Pronk, Keesman, & Barsalou, 2014; Querstret, Cropley, & Fife-Schaw, 2016; Reb & Narayanan, 2014; Wolever, et al., 2012). Of course, there is no "quick fix" when it comes to long-term benefits of those interventions directed at clinical or vulnerable populations or individuals. At the same time, less costly and time intensive interventions are needed to complement the current stream of research and to appeal to busy working adults.

In fact, finding time is an oft-cited key barrier to following through on mindfulness interventions (e.g., Rosenzweig, Reibel, Greeson, Brainard, & Hojat, 2003; Shapiro, Astin, Bishop, & Cordova, 2005). In a review of mindfulness interventions, Carmody and Baer (2009; p. 636) stated "that adaptations that include less class time may be worthwhile for populations for whom reduction of psychological distress is an important goal and for whom longer time commitment may be a barrier to their ability or willingness to participate." Such abbreviated interventions as those referenced have potential to broaden mindfulness' availability and use in the general population.

In addition to the practical methodological benefits, brief mindfulness interventions are important to study from a theoretical standpoint. As Brown, Creswell, and Ryan (2015; p. 211) state, “one-time mindfulness inductions are best conceptualized as the smallest “dose” of mindfulness that can be studied to assess the immediate impact of mindful states, representing one end of the mindfulness training continuum…the quality of mindfulness induced during these brief manipulations is unlikely to approach the quality of mindfulness induced during long-term training. Nevertheless, this approach can be valuable for isolating or elucidating the immediate emotional effects of mindful states.” Indeed, evidence shows that one-time mindfulness inductions have been shown to be effective at reducing reactions to acute stressors (Jones, 2013; Larson, Steffen, & Primosch, 2013; Steffen & Larson, 2015).

This study further advances the call for practical mindfulness interventions that could be applied in the workplace realm. Specifically, it was designed as a high impact, one-time intervention in order to examine mindfulness’ immediate effects on vigilance performance. As discussed, breaks allow for recovery on the job (Baumeister et al., 1998), particularly in safety-critical vigilance contexts (Ross et al., 2014). This study explores the extent to which mindfulness augments such breaks. I further detail the intervention below.

Participants

One-hundred and five individuals participated in this study. Participants included undergraduate students at a Midwestern university interested in participating in research. To meet the rule of thumb of 10 participants per parameter (Schreiber, Nora, Stage, Barlow, & King, 2006; Kline, 2005), my desired sample size was 100 in order to have sufficient power to test hypotheses (e.g., Bentler & Chou, 1987).

First, assumptions of univariate and multivariate normality as well as homogeneity of variance were assessed and met. In total, four participants were eliminated for the purposes of analyses – three participants' data were dropped due to excessive missing data (nearly all data were missing – one dropped from the study, one experienced technical difficulties, and one had missing data for an unknown reason). One participant's data were dropped for reporting that he/she did not follow the manipulation instructions (answered 1 (Very Little) on a 5-point scale). The final sample size was therefore 101.

Of the final sample, 65% of participants identified as female, and 35% of participants identified as male. The average age was 23.5; ages ranged from 19 to 58. 89.1% of participants identified as Non-Hispanic. Further, 68.3% of participants identified as White or Caucasian, 9.9% identified as Black or African American, 7.9% identified as Latino or Latina, 4.0% identified as East Asian American, 3.0% identified as South Asian American, 1.0% identified as American Indian or Alaskan Native, and 5.9% of participants more strongly identified with another race altogether. Finally, 76.2% of participants were employed. Of those employed, 76.6% were employed on a part-time basis. Represented industries are in Table 1. At the end of the study, participants were also asked how much experience they had in jobs in which they monitored for rare events, similar to the X-Ray screening task in which they looked for rare weapons. Examples were provided (monitoring for drowning people as a lifeguard; looking for suspicious behavior as a security guard; monitoring patient vital signs as a nurse).

Though the majority of participants had no or little experience with such tasks (57.4%), 7.9% of participants had a lot of experience, 11.9% of participants had quite a bit of experience, and 19.8% of participants had some experience.

Table 1

Industries Represented in Sample

Industry	Percentage
Childcare	3.9%
Construction	1.3%
Education	6.5%
Finance	5.2%
Healthcare	16.9%
Hotel	0%
Legal	0%
Restaurant	16.9%
Retail	15.6%
Other	33.8%

Procedure

Participants were first randomly assigned to an experimental mindfulness condition or a control condition and introduced to the study. In both conditions, each participant first completed a pre-experiment survey of basic demographic information (e.g., sex, age, ethnicity, race). Next, each participant received a brief training session on the X-ray screening task (Merritt, 2011; see Appendix B for training materials), which will be discussed in more detail below.

Next, they completed a block of the X-ray screening task as a baseline measure of vigilance performance. Following the task, participants completed baseline measures of mental workload and stress. At this time, participants received the experimental manipulation by either participating in a mindful breathing exercise (experimental condition) or an unfocused awareness exercise (control condition), described below. During this exercise, the experimenter sat in a different room to create a more relaxing environment conducive to focusing on the manipulation. Three very brief items were administered following the manipulation measuring state mindfulness, stress, and mental workload. Next, participants immediately engaged in a second X-ray screening block, followed by measures of mental workload and stress. At the end of the study, participants received a manipulation check, assessing the extent to which they were or were not in a mindful state during the manipulation. They were also asked questions to examine whether they complied with the instructions in the X-ray screening task and in the manipulation. Finally, participants completed a series of self-report measures described below. After completing the study, all participants had the option to receive a take-home sheet of mindfulness resources (regardless of assigned condition). They also received a debriefing statement. See Figure 3 for a summary of the study's procedure.

Experimental Manipulations

Each participant was randomly assigned to an experimental mindfulness intervention (i.e., focused breathing) or a control (i.e., unfocused attention) condition. Participants wore headphones and, based on assigned condition, listened to different 15-minute teachings, from Arch and Craske's (2006) script, originally derived from Kabat-Zinn's (1990) Mindfulness Based Stress Reduction program. In each condition, participants received the same introductory instructions prior to beginning the task. Because the idea of mindfulness may be novel to many participants, one component of the instructions acknowledged this reality. The instructions were as follows: "Now we're going to do an exercise for 15 minutes. First, settle into a comfortable sitting position. Though you may find the next activity to be unique, you are encouraged to embrace it. Please get comfortable, relax, and follow the instructions to the best of your ability for this short 15-minute exercise.” Participants were aware of task length as evidence indicates that when participants are uninformed, the task may not allow for recovery as it essentially becomes another vigilance task in which one wonders when it will end (Lim, Catherine-Quevenco, & Kwok, 2013). See Appendix B for a full script of each recording.

***Mindfulness Condition*.** Participants randomly assigned to the mindfulness intervention went through an audio-guided mindfulness teaching – specifically, focused breathing. This is an introductory mindfulness exercise developed by Arch and Craske (2006) to induce a mindful state. It has been used and further adapted in a number of studies (e.g., Feldman, Greeson, & Senville; 2010; Hafenbrack, Kinias, & Barsade, 2014; McHugh, Simpson, & Reed, 2010; Ruedy & Schweitzer, 2010). Given that this sample mostly included participants who are new to mindfulness (non-practitioners), the exercise was called “focused breathing” to increase its acceptability and reduce demand characteristics. In this exercise, participants were guided through an exercise with the goal of simply concentrating on the quality of their breath without trying to manipulate or control it. Participants were instructed to recognize and receive any thoughts or emotions that arose without lingering on them, refocusing on their moment-to-moment experience. Specifically, participants were instructed to “focus on the actual sensations of breath entering and leaving the body. There is no need to think about the breath—just experience the sensations of it. When you notice that your awareness is no longer on the breath, gently bring your awareness back to the sensations of breathing.’’ Adaptations of these instructions were intermittently repeated (every 30-60 seconds) for the remainder of the 15-minute exercise.

***Control Recovery Condition*.** Participants randomly assigned to the control condition were given the same amount of time allotted in the mindfulness intervention. This exercise was also adapted from Arch et al. (2006). Participants in the control condition were given a break after each block where they engaged in an “unfocused attention” exercise in which they were instructed to think about whatever their mind took them, as they generally do throughout the day. To increase standardization and consistency across conditions, participants received a comparable amount of guided instruction throughout the exercise. The participants were instructed to ‘‘simply think about whatever comes to mind. Let your mind wander freely without trying to focus on anything in particular.” Just like the mindfulness condition, similar instructions were intermittently repeated throughout the course of the exercise. This particular recovery exercise was chosen in order to find a balance between 1) paralleling the somewhat unstructured nature of task breaks in most jobs and 2) creating a degree of standardization in order to compare results across conditions. Other studies have also utilized this exercise as a control condition as evidence such as neuroimaging studies indicates this freethinking state exemplifies the default or baseline mode in which individuals generally operate (Buckner, Andrews-Hanna, & Schacter, 2008; Mason et al.., 2007).

Measures and Materials

X-Ray Screening Task. The X-ray screening task was designed by Merritt and Ilgen (2008). This computer-based simulation is a simplified adaptation of a real-life safety critical situation which allows for experimental control. In today’s current climate of increased transportation threat and security, this task should be relevant to participants and the implications of effective or ineffective performance on such a task should have been highly salient, thus increasing intrinsic motivation to perform well. In this task, participants inspected 45 X-ray images per task block. Each image depicts a suitcase containing various items. 20% of the images contain weapons (i.e., guns or knives). Each image varies in difficulty. Simpler images contain fewer items with an easy-to-identify weapon whereas more complex images contain a number of overlapping items with a more disguised weapon. For example, Figure 4 shows a less complex image, and Figure 5 shows a more complex sample image that contains a disguised gun. To further mirror real-life conditions which increase task demands, and to increase the fidelity of the study, each participant wore headphones and listen to an audio recording of noises similar to what one would hear in an airport. Participants either responded that they wished to “search” the bag if they thought it held a weapon or “clear” the bag if they did not think it held a weapon.

Vigilance Performance. In each X-ray screening block, participants accrued points for every accurate decision. The scoring system was as follows: +500 points for a hit (weapon correctly detected), -500 points for a miss (weapon present but not detected), +100 points for a correct rejection, and -100 points for a false positive. The point system was designed such that higher awards and deductions were given when a weapon was present to mirror the critical task of preventing weapons from making it through security. For example, arguably, false positives have less consequence than misses. For each block, vigilance performance was operationalized as the amount of points a participant accumulated.

State Mindfulness. As a manipulation check, a measure of state mindfulness was administered to participants in both conditions after the final X-ray task to assess the extent to which individuals believed they were in a mindful state during the recordings. The state-based Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003) was administered; several exploratory items were added as well, including state-based items from Freiburg Mindfulness Inventory (Walach et al., 2006). The 10-item scale demonstrated sound internal consistency ($\alpha = .74$). Slight word modifications were used to change the frame of reference to reflect the participant's current experience. Directions asked: "To what degree were you having the following experiences during the audio recording?" Items include "I found it difficult to stay focused on what was happening in the present" and "I was eager to rush through the task without being really attentive to it." Items were on a 5-point scale from Not at all (1) to Very much (5).

Subjective Stress. The Short Stress State Questionnaire (SSSQ; Helton, 2004) was administered as a subjective measure of task-based stress following both X-ray screening tasks. The X-ray screening task was used as the situational frame of reference. Thus, each item began with "During the X-ray Screening Task …" A sample item includes, "I felt self-conscious." Response options ranged from "Not at all" (1) to "Extremely" (5). This 8-item scale demonstrated sound internal consistency both pre- and post-intervention (Time 1: $\alpha = .77$; Time 2: $\alpha = .83$).

Mental Workload. The NASA TLX (Task Load Index; Hart & Staveland, 1988) was administered following both X-ray screening tasks as well. For this study, I examined mental fatigue, temporal demand, effort, and frustration level. The scale also measures physical demand and performance, but these were left out of analyses because the task is not physically demanding; further, the performance item was worded opposite of the other items causing response issues. Research shows mental fatigue and frustration level are the most important constructs in a vigilance context. Questions were asked on a 10-point scale ranging from Low (1) to High (10) (e.g., “How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?”). This scale is widely used in vigilance research. The 4-item scale demonstrated sound internal consistency (Time 1: $\alpha = .77$; Time 2: $\alpha = .75$).

Brief Post-Manipulation Items. Though the full scales most directly related to the hypotheses were administered after the X-ray task so as not to hurt the mindfulness induction, in order to examine if the mindfulness intervention had immediate effects, additional brief exploratory items were asked immediately after the recordings: one item for stress, one item for working memory, and one item for state mindfulness. The stress item was used in Weinstein et al. (2009) and asks ‘‘How much stress are you experiencing right now?” It was rated on a five-point Likert scale ranging from None (1) to A Lot (5). The working memory item asks, “Right now, how much mental demand are you experiencing?” It was rated on the same Likert scale. Finally, the state mindfulness question was adapted from Walach et al.’s (2006) Freiburg Mindfulness Inventory and states, “During the recording you just listened to, how connected did you feel to your experience in the “here-and-now” (rather than thinking about your experiences before or after the recording)? It was rated on a five-point Likert scale ranging from Not at all connected to the “here and now” (1) to Highly connected to the “here and now” (5). These same items were administered post-intervention to allow for direct comparison.

Compliance with Instructions. Participants were also evaluated on the extent to which they followed the instructions for both the X-ray task as well as the experimental and control audio recordings. For the X-ray task, individuals received three "easy" X-ray slides (two in Block 1, and one in Block 2) in which weapons were clearly visible. All participants answered correctly, and thus, it was evident participants were paying attention. Page timers were also included on each X-ray slide so that insufficient effort responding could be further examined. Two participants spent more time on the X-ray task compared to other participants (12-13 minutes compared to an average of 6-7 minutes on Block 2), but no one emerged as an outlier for spending too little time on the task. After the X-ray screening task, participants were also asked one question about self-efficacy: "How confident did you feel in carrying out this task?" (ranging from "Very Little" (1) to "Very Much" (5)). To check for compliance with the manipulation, participants were asked, "How would you rate the extent to which you tried to follow the (focused breathing or unfocused attention) audio-recorded instructions to the best of your ability?" (ranging from "Very Little" (1) to "Very Much" (5)). Moreover, participants were asked how much they enjoyed and found the break useful ("To what extent did you enjoy the break?" (ranging from "Not at all" (1) to a "A Great Deal" (5)), "To what extent did you feel the break was a good use of your time?" (ranging from "A very good use of time" (1) to "A very poor use of my time" (5)).

Working Memory. An automated version of the Stroop Task (Golden, 1978; MacLeod, 1991; Stroop, 1935) was administered through Inquisit as a supplemental behavioral measure of participants' working memory. During this task, individuals were shown words in various colors and tasked with saying the appropriate color. The task is difficult, though, as the word and font color may be congruent or incongruent. For example, the word "green" may be shown in the color green (congruent) or in the color red (incongruent). An incongruent word (e.g., the red-colored word “green”) tends to trigger more errors as participants have a propensity to say the *word* as opposed to the *color* of the word. The goal is the override this inclination in order to say the actual color. When one is under cognitive load, performance on this task tends to be poorer; thus, performance reveals availability of cognitive resources and is a proxy for working memory. This task was only administered post-test, as a pre-test was expected to impose too much cognitive load which could have interfered with the manipulation. It was thus administered after the final X-ray screening task as a supplemental measure of working memory.

Trait Mindfulness. The 14-item short-form of the Freiburg Mindfulness Inventory (Walach et al., 2006) was used to assess trait mindfulness. The instructions for this measure say, “In general…,” and the items were worded in present tense (i.e., “In general, I am open to the experience of the present moment.”). The scale demonstrated sound internal consistency ($\alpha = .82$). Response options range from “Never” to “Almost Always.” This scale was administered at the end of participants’ time in the lab. It was for exploratory purposes and not core to the hypotheses.

General Stress. This supplemental two-item measure (Gaab et al., 2003) was administered to examine participants’ general levels of stress. Items were “At this moment, I feel stress by the situation” and “At this moment, I feel calm and relaxed.” These items were administered both pre- and post-intervention. Internal consistency estimates were .84 at Time 1 and .67 at Time 2. This scale was for exploratory purposes and not core to the hypotheses.

Challenge-Threat Scale. This supplemental scale (Drach-Zahavy & Erez, 2002) was administered to examine the extent to which participants reported approaching the task from a challenge and/or threat mindset. The items were modified to be past tense and administered at the end of the study so as not to overwhelm or add additional strain on participants in the more critical portion of the study. An example "challenge" item is "The task provided opportunities to overcome obstacles." An example "threat" item is "I was worried that the task might reveal my weaknesses." Both scales had sound internal consistency (challenge: α =77; threat: α =.80). Response options ranged from Strongly Disagree (1) to Strongly Agree (5). This scale was for exploratory purposes and not core to the hypotheses.

Sleep Quality. The 8-item Epworth Sleepiness Scale (ESS; Johns, 1991) was administered to assess state sleepiness. The scale was adapted to ask about the likelihood that one may "doze off or fall asleep in the following situations *at this moment,* in contrast to just feeling tired." This adaption has been used by other researchers such as Barber and Budnick (2015). The scale demonstrated sound internal consistency (α =.74). The scale uses eight situations as the frame of reference such as "Sitting and talking to someone" and "Watching TV." Response options are on a 5-point Likert scale ranging from "Very little or no chance of dozing" to "very great chance of dozing." This supplemental scale was administered at the end of participants' time in the lab. This scale was for exploratory purposes and not core to the hypotheses.

Caffeine Consumption. One four-part question was asked to assess caffeine consumption (adapted from Brick, Seely, and Palermo, 2010). They were asked to indicate "How many servings (e.g., 1 cup, 1 can) of the following caffeinated beverages have you had so far today?" The beverages are coffee (average of 130 mg of caffeine per serving), soda (average of 35 mg of caffeine per can), tea (average of 36 mg of caffeine per serving), and energy drinks (average of 95.5 mg of caffeine per serving). The relative caffeine quantity for each beverage (as reported by Mayo Clinic) was added to total the number of milligrams of caffeine consumed that day, which was used in analyses. This item was for exploratory purposes and not core to the hypotheses.

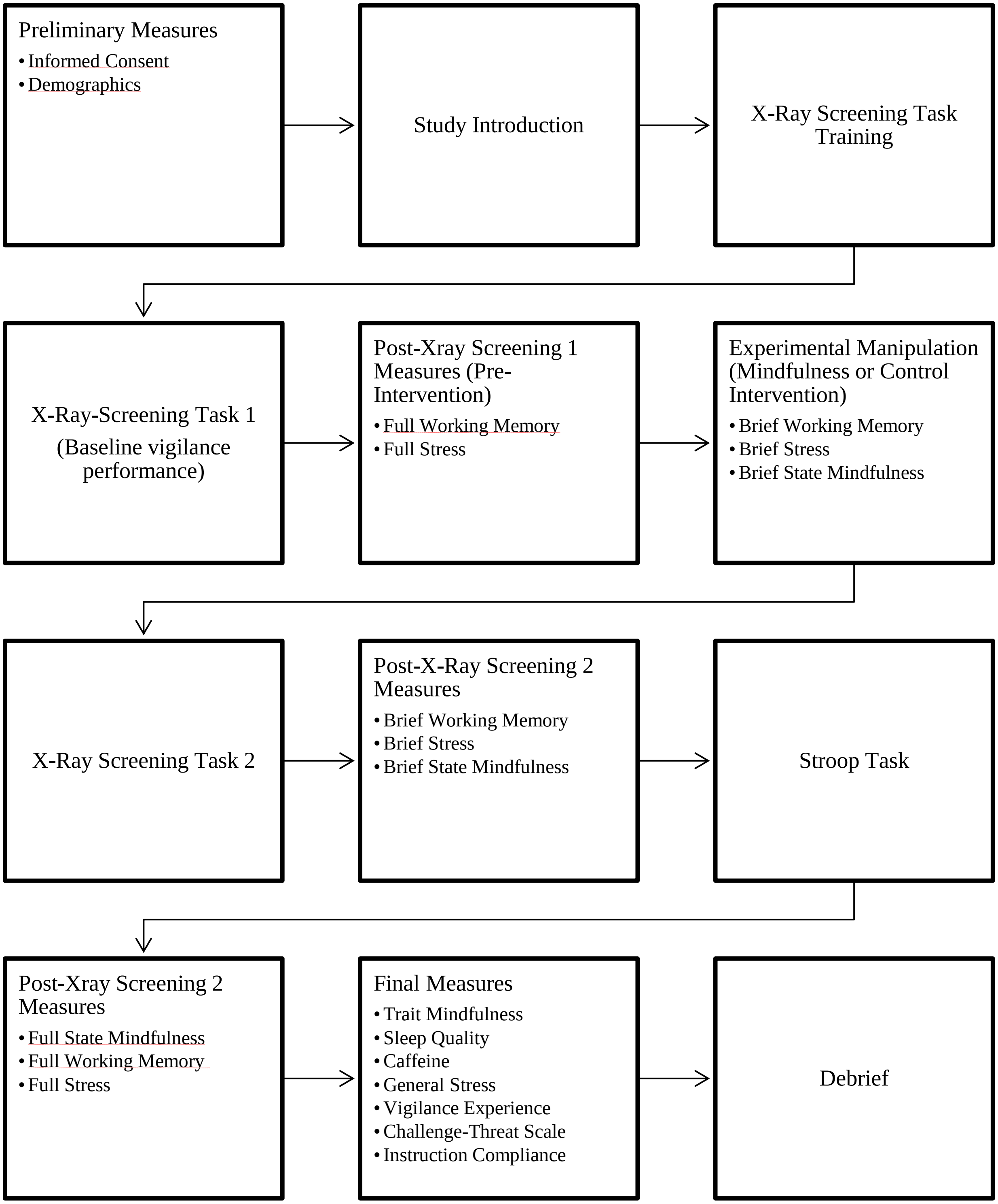


Figure 3. Study procedure.

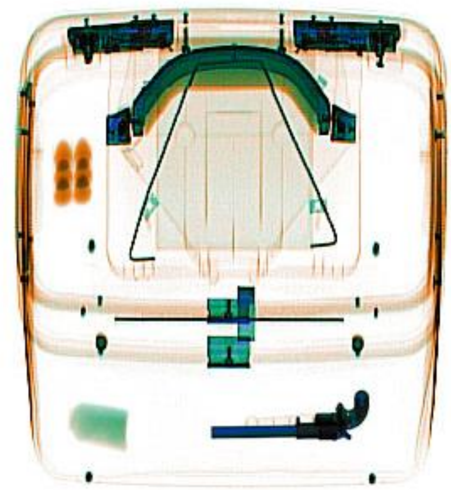


Figure 4. X-Ray Screening Task Sample Easy Image

Figure 5. X-Ray Screening Task Sample Difficult Image

Results

First, I assessed the assumption that the conditions did not significantly differ on demographic variables or any of the outcomes of interest at baseline using *t*-tests. The conditions did not significantly differ on any demographic variables. The conditions also did not differ on core variables of interest: working memory, stress, or vigilance performance at pre-test. However, though a supplemental variable, findings indicated that conditions differed on levels of trait mindfulness ($t(99) = -2.13$ $p = .04$). Interestingly, those in the control condition reported significantly higher levels of trait mindfulness (M = 3.53, SD = .50) than those in the experimental condition (M = 3.32, SD = .50). This was surprising given participants were randomly assigned to conditions\. It is possible this finding could have impacted the study's findings to some degree. Measures of both trait and state mindfulness are explored further below.

A manipulation check was conducted to examine the extent to which the mindfulness induction was effective at promoting a mindful state relative to the control condition. Results showed that conditions did not significantly differ on levels of state mindfulness (full state mindfulness measure asked at the end of the experiment: $t(99) = -.39$, $p = .70$, M = 3.46 for mindfulness condition and 3.51 for control condition; one-item measure asked immediately after the manipulation: $t(98) = 1.18$, $p = .24$, M = 3.35 in the mindfulness condition and 3.12 in the control condition). Thus, the intervention may not have been robust enough to elicit change in levels of mindfulness.

Hypothesis Tests

I used path analysis with Hayes's (2018) PROCESS macro (version 3; Model 6) in SPSS to examine hypotheses. This allowed me to a.) evaluate the significance of individual relationships (Hypotheses 1, 2, 3, and 5), b.) examine whether stress and mental demand mediated a relationship between experimental condition and vigilance performance (Hypotheses 4 and 6), and c.) control for pre-intervention scores. Valente and MacKinnon (2017) as well as Hayes (2018) recommend using baseline (pre-intervention) scores as covariates. This allows one to control for variance in stress, mental demand, and vigilance performance unrelated to the manipulation in order to more precisely estimate variance associated with the mindfulness intervention. This approach bolsters internal validity. In this case, Time 1 stress, mental demand, and vigilance performance were assigned as "lag" variables in their respective equations within the larger model. As an example, Time 1 stress was only assigned as a covariate of Time 2 stress in all examined models, not as a covariate of *all* variables (e.g., vigilance performance). This allowed for increased specificity in analyses.

First, I dissected individual relationships (Hypotheses 1, 2, 3, and 5). Results revealed that participants in the mindfulness condition did not significantly differ from those in the control condition in terms of stress (b = -.17, t = -1.54, p = .13; CI = [-.39, .04]) or mental demand (b = .09, t =.40, p = .69; CI = [-.37, .58]), providing no support for Hypotheses 3 and 5, respectively. Figures 6 and 7 in the appendix show average stress and mental demand by condition pre- and post-manipulation. This may be because conditions did not significantly differ on levels of state mindfulness, thus limiting the ability to fully assess these relationships. In line with previous research, stress was indeed related to mental demand (b = .41, t =2.49, p = .01; CI = [.08, .72]); for every 1-point decrease in stress, mental demand decreased by .41.

Next, I examined the degree to which stress and mental demand were related to Time 2 vigilance performance. Findings showed stress did not significantly correlate with vigilance performance (b = 11.82, t = .06, p = .95; CI = [-350.69, 403.79]); thus, Hypothesis 1 was not supported. Further, while the relationship between mental demand and vigilance performance was marginally significant (b = 157.59, t = 1.85, p = .07, CI = [-28.91, 326.34]), it was not in the expected direction. Rather than increased mental demand being negatively associated with performance, the relationship was instead positive – perhaps suggesting that those who devoted more mental effort to the task performed better. Thus, Hypothesis 2 was also not supported. It was predicted that less mental demand would free up cognitive resources important for vigilance tasks. Instead, these results are in line with previous studies showing vigilance tasks are inherently and subjectively cognitively challenging and require mental effort to perform well. Figure 8 shows average vigilance performance by condition pre- and post-manipulation. As shown, level of performance was quite similar by condition.

Predictions that stress and mental demand would operate as mediators were also not supported. Hypotheses 4 and 6 predicted that mindfulness would reduce task-based stress and mental demand, in turn, bolstering vigilance performance. To evaluate whether each indirect effect was statistically significant, the bootstrap method was used, generating 10,000 bootstrap samples to compute confidence intervals. This technique allows one to conclude, with 95% confidence, whether the true indirect effect lies within two values. Results did not support either indirect effect hypothesis. Thus, Hypotheses 4 (stress as a mediator: ab = -2.01, SE = 38.23, CI = [-76.87, 85.53] and Hypothesis 6 (mental demand as a mediator: ab =15.53, SE = 46.54, CI = [-62.16, 132.37]) were not supported. Results also did not support Hypothesis 7, the prediction of a serial indirect effect through both stress and mental demand (a*b* = -10.97, *SE* = 11.46, CI = [-39.06, 3.62]). Figure 9 illustrates this model's standardized path coefficients. Table 2 shows this model's unstandardized indirect effects (see appendix; Hypothesized Sequential Mediation Model). Means, standard deviations, and correlations between condition, pre- and post-intervention stress, mental demand, and vigilance performance are reported in Table 3 below. Correlations separated by condition are reported in Table 4.

Post-Hoc Analyses

Impact of Pre-Stress and Pre-Mental Demand

First, to explore the above findings, baseline levels of stress and mental demand were further examined. Moderation analyses revealed that condition interacted with each of these variables to significantly affect vigilance performance (pre-stress: b^3 = 998.52, $t(96)$ = 2.65, p = .01; pre-mental demand: b^3 = 327.74, $t(97)$ = 2.00, p = .05). More specifically, pre-stress and pre-mental demand were positively associated with vigilance performance in the control condition (pre-stress: r = .27, $p < .05$; pre-mental demand: r = .29, $p < .05$). On the other hand, in the mindfulness condition, pre-stress was negatively associated and pre-mental demand was not significantly associated with vigilance performance (pre-stress: r = -.26; $p < .05$; pre-mental demand: r = .08, $p > .05$). This suggests that if individuals reported higher levels of stress and mental demand after the first baggage screening block (thus, were more drained going into the intervention), the mindfulness induction may have further taxed them as these individuals subsequently performed worse on the second baggage screening block. On the other hand, if one reported lower levels of stress and mental demand after the first block, the mindfulness induction was associated with higher performance in the second block.

The reverse was discovered for the control (unfocused attention) condition. After reporting higher levels of stress and mental demand after the first block, individuals who experienced the control condition performed more strongly on the second block. However, if one was not feeling taxed after the first block, the control condition may have further disengaged individuals as it was associated with worse vigilance performance on the second block. See Figures 10 and 11 in the appendix for graphs of each moderated relationship. Though associations trended in the same direction for post-stress and mental demand, results were not significant. These findings offer implications regarding the conditions under which state mindfulness interventions may be most effective.

Stroop Task

The Stroop Task (Golden, 1978; MacLeod, 1991; Stroop, 1935) was administered as a more objective, behavioral measure of mental demand. When one is under cognitive load, performance on this task tends to be poorer. Stroop response time was examined in the hypothesized model describe above, replacing subjective mental demand. The mindfulness intervention and stress were not related to Stroop response time, and there was no significant indirect effect on vigilance performance (ab = 8.21, SE = 13.66, CI: [-5.49, 46.49]). However, findings supported the prediction that better Stroop reaction times (thus, more cognitive resources) would be directly related to stronger vigilance performance (b = -1.00, t = -2.68, p = .01, CI = [-1.74, -.26]). Figure 12 illustrates this model's standardized path coefficients. Table 5 provides its unstandardized indirect effects (Objective Mental Demand (Stroop) as Mediator).

Notably, subjective and objective mental demand were not significantly related ($r = -.01$, $p = .96$). This is consistent with other findings that indicate subjective and objective measures of mental demand are often divergent (e.g., Dwyer & Ganster, 1991). Further, this finding suggests that while higher subjective mental demand (*perceptions* of working memory depletion) is correlated with better vigilance performance, lower objective mental demand (*actual* levels of cognitive resources) is correlated with better vigilance performance.

Alternative Measures of Mindfulness

Both trait and state mindfulness were measured as well. Because the mindfulness intervention did not have a significant effect on key outcomes, trait and state mindfulness were averaged across conditions in the remaining post-hoc analyses. Thus, the remaining results are not a comparison of the experimental vs. control condition, but rather, an examination of the effects of measures of trait and state mindfulness independent of condition.

Primary Threat and General Stress

Primary Threat. In addition to assessing pre- and post-intervention task-related stress, other measures of stress were administered as well. First, primary threat was measured. Goal-related threat is felt when one perceives a goal to be overly taxing. That is, one feels too few coping resources are available to manage demand (Drach-Zahavy & Erez, 2002). In this case, if one experienced high levels of primary threat, the vigilance task may have been perceived as risky or threatening; one might also perceive a higher chance of failure.

Results revealed that state mindfulness exhibited a significant indirect effect and trait mindfulness exhibited a marginally significant indirect effect on vigilance performance through primary threat and mental demand (state mindfulness: *ab* = -23.48, *SE* = 16.83, CI = [-63.83, -1.00]; trait mindfulness: *ab* = -26.91, *SE* = 19.57, CI: = [-75.12, .17]). State and trait mindfulness had a significant effect on primary threat (state mindfulness: *b* = -.26, *t* = -2.18, *p* =.03; CI = [-.47, -.06]; trait mindfulness: *b* = -.33, *t* = -2.24, *p* = .03, CI = [-.58, -.06]) such that mindfulness was related to lower levels of primary threat. Lower primary threat was then related to lower mental demand (state mindfulness model: *b* = .42, *t* = 2.44, *p* = .02, CI = [.10, .79]; trait mindfulness model: *b* = .40, *t* = 2.31, *p* = .02, CI = [.07, .77]) which in turn was related to vigilance performance (state mindfulness model: *b* = 2.12.48, *t* = 2.52, *p* = .01, CI = [45.69, 371.33]; trait mindfulness model: *b* = 206.35, *t* = 2.45, *p* = .02, CI = [42.95, 363.42]). Again though, mental demand was positively related to vigilance performance, further highlighting the cognitive difficulty of vigilance performance. Figures 13 and 14 display these models' standardized path coefficients, and Table 6 shows these models' unstandardized indirect effects (Primary Threat and Mental Demand Sequential Mediation Model).

General Stress. More general levels of Time 2 stress were also examined (e.g., I feel calm and relaxed). Results revealed that trait mindfulness was significantly related to lower levels of Time 2 general stress (*b* = .43, *t* = -2.60, *p* = .01, CI = [-.71, -.13]), controlling for Time 1 general stress. In turn, decreased stress was related to less mental demand (*b* = .55, *t* = 4.64, *p* = .00, CI = [.29, .79]). After controlling for pre-intervention levels of stress and mental demand, these constructs did not predict vigilance performance nor were there any significant indirect effects. When examining state mindfulness in the same model, results revealed no significant effects on general stress, mental demand, or vigilance performance. Figures 15 and 16 illustrate these models' standardized path coefficients, and Table 7 shows these models' unstandardized indirect effects (General Stress and Mental Demand Sequential Mediation Model).

Vigilance Performance – Difficult Trials Only

In the vigilance task, X-ray images ranged from easy to difficult. Follow-up analyses were conducted to examine the degree to which mindfulness might impact one's ability to detect threats in images with more noise and, thus, higher likelihood of error. A model examining trait mindfulness, general stress, and mental demand revealed that trait mindfulness was directly and significantly correlated with performance on the difficult images (b = 561.70, t = 2.23, p = .03, CI = [27.63, 1045.16]), controlling for Time 1 scores of mental demand, stress, and vigilance performance on difficult trials. An examination of the same model using state mindfulness as a predictor revealed that state mindfulness was not significantly associated with performance on difficult trials (b = 117.00, t = .56, p = .58, CI = [-310.06, 503.84]). Further, no indirect effect between trait and state mindfulness on vigilance performance through stress and mental demand was found. Figures 17, 18, and 19 illustrate these models' standardized path coefficients, and Table 8 shows these models' unstandardized indirect effects (Various Models – Difficult Trials Only).

While the overall trait mindfulness construct was predictive, examining its specific dimensions (attention and acceptance) further elucidate these findings. The components exhibited differential predictive strength such that acceptance was more predictive of performance in difficult trials (acceptance: $r = .21$, $p < .05$; attention: $r = .10$; $p > .05$). That is, findings revealed that one's ability to bring a non-judgmental and less emotionally reactive appraisal to his/her moment-to-moment experience carried more weight than one's ability to stay anchored in the present moment.

All in all, the unique finding in this model is that trait mindfulness is significantly related to one's ability to perform well on more complex vigilance tasks. At the same time, because trait mindfulness significantly differed between conditions, it was important to examine the extent to which the study's manipulation might have had an effect on these findings; results revealed condition was *not* directly or indirectly related to performance on difficult trials. This increases confidence in the finding that trait mindfulness levels are predictive of performance in this context, independent of condition effects. This discovery is promising given that 1) difficult vigilance tasks often have safety implications and 2) trait-based mindfulness can be developed with practice (e.g., Kiken, Garland, Bluth, Palsson, & Gaylord, 2015). Implications are discussed below.

Comparison to Common Vigilance Predictors

A final supplemental goal of this study was to examine the relative importance of mindfulness and other traditional predictors of vigilance performance. Thus, a stepwise regression was examined to see the degree to which state and trait mindfulness might predict vigilance performance above and beyond sleep quality, caffeine intake, and vigilance experience. Interestingly, none of these variables, not even more traditional predictors of vigilance, were directly correlated with vigilance performance. However, mindfulness did demonstrate some interesting relationships with these variables. See Table 10 for a correlation table of these variables.

Sleep quality was correlated with state mindfulness ($r = -.27$, $p < .05$), suggesting those in a more restful state reported they were better able to attend to the present moment. Further, daily caffeine intake was also marginally and negatively correlated with trait mindfulness ($r = -.18$, $p = .07$). Thus, there appears to be a slight relationship between being naturally mindful and drinking less caffeine. As research shows trait mindfulness is related to higher body awareness, one hypothesis is that those higher in trait mindfulness may be wary of the negative health-related effects of caffeine. It is unclear why variables traditionally related to vigilance performance were not predictive in this case. One reason may be that these variables were subjective reports of sleep quality and caffeine intake. Future research might examine the degree to which mindfulness is related to more objective predictors of sleep quality and caffeine intake as well as examine mindfulness's predictive power in a vigilance context relative to these variables.

Discussion

Overall, this study contributes to the field's growing understanding of the potential uses of mindfulness in organizational settings. Despite predictions that an in-the-moment mindfulness induction would positively influence vigilance performance, results did not support this hypothesis. First, the mindfulness induction was not effective at inducing a mindful state compared to the control manipulation. Thus, the mindfulness induction did not yield significant effects on outcomes of interest. However, as described below, baseline levels of pre-stress and pre-mental demand may shed some light on these findings. Moreover, some promising discoveries emerged when examining general measures of trait and state mindfulness. Ultimately, the study's findings have implications for the channel by which mindfulness may be most effective in a vigilance context.

Before turning to why the intervention might have been unsuccessful, I will first discuss the study's key supported findings. First, this study extended previous findings that trait and state mindfulness are associated with lower levels of stress. In turn, lower stress was associated with lower mental demand. As stress and mental demand can deplete one's limited pool of mental resources, these findings show that mindfulness may have a protective effect on resources one draws upon when monitoring for safety critical stimuli. It would be expected that this protection of mental resources would be more important over the course of a lengthier, more complex vigil experienced in a typical workday.

Delving further into the results, it is worth noting that unique findings emerged when examining mental demand. Those who performed better on the vigilance task exerted significantly *more* mental effort (subjective ratings) but also had significantly more cognitive resources left in the tank at the end of the study (objective performance on the Stroop task). This suggests that individuals who perceived the vigilance task to be cognitively challenging but who also had more cognitive resources to spare performed better. Because devoting mental effort is important for vigilance performance, future research might explore whether there is a "sweet spot" at which mindfulness helps reduce unnecessary mental demand (e.g., negative self-talk; Frewen, Evans, Marai, Dozois, &

Partridge, 2008) without inadvertently reducing mental effort in a way that negatively impacts task performance.

Findings also revealed that both trait and state mindfulness were related to the extent to which one perceived the vigilance task to be threatening. This is in line with previous research (e.g., Weinstein et al., 2009) showing mindfulness is associated with more adaptive appraisal of stressors – in particular, viewing one's experience with a more open, approach-based mindset. In this study, this adaptive appraisal was, in turn, related to lower stress and mental demand with these variables mediating the relationship between mindfulness and vigilance performance. Given that vigilance tasks are often accompanied by emotionally charged stimuli (e.g., monitoring for patient vital signs, screening for weapons), this finding is promising. When one is exposed to such stimuli day after day, the ability to openly face one's experiences has important implications. As Dandeneau, Baldwin, Baccus, Sakellaropoulo, and Pruessner (2007) describe, effective appraisal can 1) serve as a filter that "cuts stress off at the pass" and 2) then prevent a more amplified response to stress at later points in a task.

Individuals' dispositional levels of mindfulness, in particular their ability to leverage an accepting mindset, also predicted vigilance performance on especially difficult trials. That is, individuals were better able to decipher whether a weapon was present in images with more noise and, thus, greater chance of error. One reason for this finding may be the use of more adaptive coping mechanisms that freed up mental resources. Maladaptive coping mechanisms such as rumination and catastrophizing have potentially damaging effects in vigilance contexts. They can be misinterpreted as "problem solving," when really, they can engender a preoccupation that steals precious resources. Acceptance, on the other hand, is related to less reactivity to anxious thoughts, less critical self-talk, and thus, higher overall cognitive capacity (Bishop et al., 2004). In this study, findings suggest that this softening of task-irrelevant cognition was associated with better goal-focused attention, particularly in later trials with lower signal salience.

Future research should continue to explore this relationship. Some evidence suggests that cultivating non-judgment and acceptance takes more practice than self-regulation of attention (Bishop et al., 2004). Thus, one explanation for lack of intervention findings may be that acceptance was difficult to prime with enough strength to carry over to the vigilance task. Future research might explore at what point into mindfulness practice is one able to begin cultivating a non-judgmental attitude; that is, at what "dosage" does one see an impact? Further, given that stress and mental demand were not intermediary mechanisms explaining this relationship, future research might examine other potential mediators. One to explore is flow (Csikszentmihalyi & Csikszentmihalyi, 1992), the ability to become fully immersed in a task. Previous research (e.g., Reid, 2011) has supported the connection between mindfulness and flow, and it would be interesting to see if such findings extend to complex vigilance tasks.

It is worth noting that beyond the impact of trait mindfulness, findings did reveal a brief one-item state-based measure of mindfulness administered immediately following Block 2 was significantly correlated with performance on difficult trials (r = .19; p = .05). This item was "How connected do you feel to your experience in the "here-and-now"?" It is unclear why the full state mindfulness scale failed to predict performance on difficult vigilance trials. One explanation may be that the full state mindfulness questionnaire was asked well after the vigil so as not to interrupt the completion of the Stroop task. It could be that one's level of state mindfulness was different than it was immediately following Block 2, and thus less predictive.

Limitations and Future Directions

A key limitation of this study was the mindfulness induction's failure to produce higher levels of state mindfulness than the control induction. Other studies with brief mindfulness inductions were examined to identify differences in methodology that may have impacted findings. First, it was difficult to identify studies that leveraged a mindfulness induction immediately *after* subjecting participants to a stressful, cognitively taxing task. This is perhaps the biggest contrast between this study and other mindfulness induction studies as most administer the brief intervention *before* participants perform such a task (e.g., Arch & Craske, 2006; Eddy, Brunyé, Tower-Richardi, Mahoney, & Taylor, 2015; Kiken & Shook, 2011; Liu, Wang, Chang, Chen, & Si, 2012; Steffen & Larson, 2015; Winning & Boag, 2015). The purpose of our approach was to have pre-test levels of stress, mental demand, and performance to more effectively establish any causal relationship that might exist.

Findings suggest that the timing of the intervention may have influenced its overall effectiveness. It was expected that mindfulness would serve as a recovery activity mid-vigil, similar to relaxation or sleep, which has been found to be effective in a vigilance context (e.g., Trougakos et al., 2008). However, when individuals were in a pre-heightened state of stress and mental demand, they may have been more vulnerable to resource depletion and subsequently performed more poorly on the vigilance task. Alternatively, when individuals entered the exercise with lower levels of stress and mental demand, they subsequently performed more strongly on the vigilance task compared to those in the control condition.

There are a couple of explanations for these findings. First, mindfulness requires concentration, and participants may have found it difficult to focus on the task if already feeling drained. These individuals may have instead experienced the mindfulness condition as *more* surprising, odd, or stressful than the control condition. This may fall in line with prior research in line with resource theory showing task switching risks adding additional strain on cognitive resources (e.g., Helton & Russel, 2012). Second, in a pre-heightened state of stress, because one purpose of the mindfulness exercise is to increase awareness of internal states, individuals may have become more aware of how stressed they were, explaining subsequent negative outcomes. Neuroscientific evidence (Lim et al., 2010) lends support for this explanation, illustrating that strained neural systems at baseline are associated with performance decay on vigilance tasks. Indeed, previous studies have shown that mindfulness can increase awareness of negative states and create discomfort in some individuals (Creswell, 2017). A central goal of mindfulness is to ultimately cultivate an acceptance towards these states which softens their effect. However, if individuals only tapped into part of the mindfulness domain (attention and not acceptance), this heightened awareness may have exacerbated their stress reaction and negatively influenced Block 2 performance.

These findings present interesting implications for *when* state mindfulness interventions might be administered. A mindfulness intervention mid-vigil, when individuals are already drained, may not be effective in this context. In fact, results show it can negatively affect vigilance performance. Instead, a true unstructured “break” may be more advantageous mid-vigil. Conversely, when individuals are able to engage in a mindfulness exercise with sufficient resources to devote to it, evidence suggests individuals may be better able to derive the benefits it has to offer and subsequently experience better performance outcomes. Future research should explore this particular finding and hypothesis. Self-reported levels of state mindfulness did not significantly differ by condition for high vs. low pre-stress and pre-mental demand groupings. Thus, future research might aim to shed light on why vigilance performance differed under these particular conditions. Future studies might also examine a mindfulness induction prior to a vigil, when individuals have more resources to devote to it, to see if such a strategy would be more effective.

Sample characteristics is another factor to explore. As this was a university sample, participants received extra credit for participation. This could have influenced motivation to fully engage in the mindfulness (and control) exercises. Moreover, this study did not recruit participants with the goal of finding those who may have been familiar with, interested in, or experienced in mindfulness. Instead, any reference to mindfulness was intentionally omitted from the recruiting materials in order to avoid a self-selection bias. It is unclear if other mindfulness induction studies are more transparent about mindfulness in recruitment. Given motivation is a key factor in mindfulness (Carmody & Baer, 2009), future studies might consider the benefits of being more upfront about the mindfulness induction. After all, in practice, engagement in mindfulness is voluntary. Future experiments might mirror such real-world conditions.

Further, some liken mindfulness to a muscle; the more it is leveraged, the more effective one becomes at the practice and the more benefits one will see. With regular practice, mindfulness may begin to feel more natural. Longitudinal studies might explore if a higher dosage leads to more positive effects than a one-time intervention in this context. At the same time, a number of participants reported that the 15-minute break was too long in length. Given that time commitment can be a barrier to leveraging mindfulness in the general population (Creswell, 2017), it is a worthwhile endeavor to continue to explore interventions that may be shorter and more practical than standard 8-week mindfulness-based stress reduction courses. For example, mindfulness phone applications may be one practical, cost-effective avenue to explore through a longitudinal study. Building interest in such applications could promote motivation. This approach could be paired with experience sampling methodology to ask for daily feedback on levels of stress and mental demand. The vigilance task could then be administered at the end of the study to see if more regular practice is associated with improved performance.

Future research might seek to answer at what stage into a mindfulness intervention do individuals begin to mirror the positive outcomes trait mindfulness demonstrated in this vigilance context. It is hypothesized that more regular practice may have more positive effects, especially given the finding that trait mindfulness was positively related to key outcomes. Indeed, research shows that a mindful disposition is developable through intentional practice (Kiken, Garland, Bluth, Palsson, & Gaylord, 2015). This finding falls in line with neuroscientific research showing regular mindfulness practice can positively alter brain structure and functioning (Hölzel et al., 2010, 2011; Lutz, Greischar, Rawlings, Ricard, & Davidson, 2004; Tang, Hölzel, & Posner, 2015) associated with self-awareness, attention, and emotional regulation.

The finding that trait mindfulness differed by condition is an interesting one and potential limitation. There are a couple of potential explanations for this. One plausible explanation in mean differences could be condition assignment as this measure was administered at the end of the study (and thus, after the manipulation). It may be that those in the mindfulness condition were *more* aware of their deficiencies in trait mindfulness after having just been exposed to an exercise in which they were asked to be mindful. Another explanation is that findings emerged due to chance. That is, despite random assignment, individuals in this condition could have just been more naturally mindful. It is worth noting that, despite significant differences between condition on this construct, actual mean differences were not sizeable. Average trait mindfulness levels (on a scale of 1 to 5) were 3.53 and 3.32 for the control and mindfulness condition, respectively. Thus, though these values are statistically different, it is debatable whether actual differences are of practical significance. Despite these differences, it is interesting that trait mindfulness still emerged as a key predictor, independent of condition. One might wonder if effects could have been even stronger had individuals not been first exposed to the study's manipulation.

The perceived usefulness of the study's break revealed interesting findings as well. Both quantitative ratings as well as anecdotal evidence were examined, and some differences between conditions emerged. When looking at ratings of break use, findings showed that the extent to which individuals 1) enjoyed the break and 2) found the break to be a good use of their time impacted state mindfulness outcomes. Interestingly, these factors were significantly associated with higher levels of state mindfulness for those in the control condition (r = .32 & .48; respectively; $p < .05$), but only approached significance in the mindfulness condition (r = .25; p = .07. & r = .24; p = .09, respectively). Further, of participants who did offer comments (45.9% in the mindfulness condition and 40% in the control condition), 25.5% in the mindfulness condition and 16% in the control condition felt the break was positive (was stress-reducing, relaxing, or enjoyable). On the other hand, 19.6% in the mindfulness condition and 24% in the control condition felt the break was not positive (was uncomfortable, stressful, too long, or boring). That is a sizeable number who felt the break, regardless of condition, was not useful.

These findings further highlight the importance of participant reactions to the break and may help explain why the mindfulness induction was less effective than predicted. Both quantitative and qualitative input reveal a high amount of variation in the degree to which one felt the break was useful. Although there is increasing interest and openness towards mindfulness (Hyland et al., 2015), additional research might explore ways to overcome barriers to its practice. Regardless of potential benefits it might offer, if individuals are resistant in some way to the intervention, its impact is limited. The timing and method by which mindfulness is delivered are worth exploring. For example, would participants be more receptive to and thus benefit more from a mindfulness intervention before a vigilance task, when they likely have more resources to devote to it? Further, would framing the mindfulness intervention in a different way help promote openness to practice? Some reluctance may stem from common misunderstandings about what mindfulness really entails (e.g., that it has to be highly “touchy feely” or only practiced by Buddhists). Research examining how to promote receptivity to mindfulness practice and its subsequent effect on outcomes would be advantageous.

This study did not communicate the purpose behind the break to reduce experimental demand, but future research might see how being intentional about communicating purpose could impact motivational factors and effectiveness. One strategy could be to introduce a mindfulness induction with education about its benefits to promote buy-in and engagement. Another strategy is to increase the salience of the connection between mindfulness and vigilance performance. For example, one could study the impact of encouraging participants to be deliberate in how they engage in a vigilance task, approaching it from a place of attention and acceptance. Other mindfulness induction studies (Erisman & Roemer 2010; Liu, Wang, Chang, Chen, & Si, 2012) have found positive outcomes after encouraging participants to approach stressful tasks in a mindful manner post-intervention.

Future research might also explore variations of this X-ray screening task. It may be that the task in this study pushed individuals to the point of mental effort but not mental fatigue. This was reflected in mental demand scores; though scores were in the top half of the scale, it was rare for anyone to use the very high end of the scale. It would be interesting to examine the impact of mindfulness in a more cognitively arduous task. In particular, increasing the length of the X-ray task would be worth exploring. This study may have tapped into maximal performance (Sackett, Zedeck, & Fogli, 1988) where individuals were generally able to successfully devote full effort given the relatively short length of the vigil (less than 10 minutes on average) One’s ability to sustain these high levels of mental effort would likely be more difficult over a longer period of time (e.g., 30-60 minutes). It would be interesting to see if higher levels of mindfulness even further predict vigilance performance in a lengthier, more complex task.

In addition, many real-life occupations regularly engage in simultaneous discrimination tasks in which employees must weigh previous information in light of new information when detecting real vs. false signals. This task did not require participants to engage in such a task. It is likely that mindfulness may have stronger comparative outcomes in a real vigilance context. While this study was performed in a controlled, lab environment with sound internal validity, it will be important for future studies to broaden the reach by examining the effects of mindfulness in field studies and with non-student samples. Such evidence would provide support for ecological validity.

In addition to examining the above, future research should explore the extent to which mindfulness augments vigilance performance in the case of emotionally disturbing stimuli. Such stimuli have been found to have a particularly detrimental impact on vigilance (Helton et al., 2011). Indeed, the stimuli in this study (guns, knives) may have elicited some negative emotions, but there is room for further exploration. One might compare a condition with negatively charged stimuli to one with more neutral stimuli, for example. This study's finding that the acceptance component of trait mindfulness was predictive may have important implications here. Because occupations that engage in vigilance tasks (e.g., military, medicine, disaster relief) face regular stressors, the ability to sustain vigilance performance in the midst of such emotionally taxing contexts is important. Some initial research (e.g., Taylor et al., 2011) suggests mindfulness may be advantageous in such contexts as it lessens emotional reactivity and promotes focus.

Unlike other vigilance recovery interventions which have mostly manipulated task design, mindfulness offers a practice under an individual's control, particularly important in occupations where little change in task design and workload is possible. This is the realty of many safety critical occupations. Additional research might explore the effects of combining both individual-based interventions such as mindfulness with task-based interventions such as advanced warning systems and audio signals to optimize vigilance performance. It will be advantageous for future studies to examine the incremental effect mindfulness offers above and beyond these predictors.

Summary

All in all, findings provide initial evidence that mindfulness may have a place in vigilance research and practice. The delivery mechanism, however, is a consideration worthy of future exploration. Although past research has shown support for brief mindfulness inductions, this study did not extend these findings, drawing into question the extent to which this may be possible in a vigilance context. Findings revealed this was particularly the case when individuals were drained going into the mindfulness exercise. At the same time, general levels of mindfulness, independent of condition, were predictive of key outcomes. As shown in prior research, these measures were associated with reduced stress, and stress was associated with lower mental demand. Given the complexity of long-duration vigilance tasks, protecting against psychological and cognitive resource depletion is important.

This study's findings also suggest that more mindful individuals are less likely to appraise a vigilance task as a threat, in turn relating to less mental demand and stronger vigilance performance. Dispositional levels of mindfulness, particularly the acceptance dimension of mindfulness, were also predictive of vigilance performance in later trials characterized by lower signal salience. This is a significant finding given such trials are more prone to vigilance failures and, thus, have deeper safety implications. One would expect this relationship to have stronger implications in more draining tasks where the vigilance decrement is starker.

Given these outcomes, building one's mindfulness muscle outside of a vigilance context may be a more effective approach than leveraging in-the-moment mindfulness inductions. This finding should continue to be explored in future research. In particular, research might examine factors that promote the effectiveness of mindfulness inductions (e.g., delivering it at the beginning, rather than in the middle, of a vigil), uncovering under what circumstances, if any, might such interventions reveal beneficial outcomes. Investigating longitudinal, experimental studies is also a worthwhile endeavor. Such research might examine the extent to which longitudinal mindfulness interventions have an effect above and beyond other interventions as well as examine the optimal amount of mindfulness practice necessary for engendering positive effects in this context.

References

Abdi, H. (2007). Signal detection theory. In N. Salkind & K. Rasmussen (Eds.), *Encyclopedia of Measurement and Statistics* (Vol. 1, pp. 887–890). Thousand Oaks, CA: Sage.

Allen, T. D., & Kiburz, K. M. (2012). Trait mindfulness and work–family balance among working parents: The mediating effects of vitality and sleep quality. *Journal of Vocational Behavior, 80,* 372-379. https://doi.org/10.1016/j.jvb.2011.09.002

Andreasen, A. K., Spliid, P. E., Andersen, H., & Jakobsen, J. (2010). Fatigue and processing speed are related in multiple sclerosis. *European Journal of Neurology*, *17*, 212-218. doi: 10.1111/j.1468-1331.2009.02776.x

Arch, J. J., & Craske, M. G. (2006). Mechanisms of mindfulness: Emotion regulation following a focused breathing induction. *Behaviour Research and Therapy*, *44*, 1849-1858. doi: 10.1016/j.brat.2005.12.007

Ariga, A., & Lleras, A. (2011). Brief and rare mental “breaks” keep you focused: Deactivation and reactivation of task goals preempt vigilance decrements. *Cognition*, *118*, 439-443. doi: 10.1016/j.cognition.2010.12.007

Aurelius, M. (1957). *Meditations*. (G. Long & P. McPharlin, Trans.). (1st Ed., pp. 47). Mount Vernon, NY: The Peter Pauper Press. (Original work composed C. 169)

Baer, R. A. (2003). Mindfulness training as a clinical intervention: A conceptual and empirical review. *Clinical Psychology: Science and Practice*, *10*, 125-143. doi: 10.1093/clipsy.bpg015.

Bakker, A. B., & Demerouti, E. (2007). The job demands-resources model: State of the art. *Journal of Managerial Psychology*, *22*, 309-328. https://doi.org/10.1108/02683940710733115

Balkin, T. J., Horrey, W. J., Graeber, R. C., Czeisler, C. A., & Dinges, D. F. (2011). The challenges and opportunities of technological approaches to fatigue management. *Accident Analysis & Prevention*, 43, 565-572. doi: 10.1016/j.aap.2009.12.006

Barber, L. K., & Budnick, C. J. (2015). Turning molehills into mountains: Sleepiness increases workplace interpretive bias. *Journal of Organizational Behavior*, *36*, 360-381. doi: 10.1002/job.1992

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: is the active self a limited resource? *Journal of Personality and Social Psychology*, *74*, 1252-1265.

Beatty, J., Ahern, S. K., & Katz, R. (1977). Sleep deprivation and the vigilance of anesthesiologists during simulated surgery. In R. Mackie (Ed.), *Vigilance: Theory, Operational Performance, and Physiological Correlates* (Vol. 3, pp. 511-527). New York: Springer US.

Beaumont, M., Batejat, D., Pierard, C., Coste, O., Doireau, P., Van Beers, P., ... & Lagarde, D. (2001). Slow release caffeine and prolonged (64-h) continuous wakefulness: effects on vigilance and cognitive performance. *Journal of Sleep Research*, *10*, 265-276.

Bentler, P. M., & Chou, C. P. (1987). Practical issues in structural modeling. *Sociological Methods & Research*, *16*, 78-117.

Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., ... & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, *11*, 230-241. doi: 10.1093/clipsy.bph077

Brick, C. A., Seely, D. L., & Palermo, T. M. (2010). Association between sleep hygiene and sleep quality in medical students. *Behavioral Sleep Medicine*, *8*, 113-121. doi: 10.1080/15402001003622925

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology*, *84*, 822-848. http://dx.doi.org/10.1037/0022-3514.84.4.822

Brown, K. W., Ryan, R. M., & Creswell, J. D. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry*, *18*, 211-237. https://doi.org/10.1080/10478400701598298

Brown, K. W., Ryan, R. M., Creswell, J. D., & Niemiec, C. P. (2008). Beyond me: Mindful responses to social threat. In H. A. Wayment & J. J. Bauer (Eds.), *Decade of behavior. Transcending self-interest: Psychological explorations of the quiet ego* (Vol. 1, pp. 75-84). Washington, DC, US: American Psychological Association. http://dx.doi.org/10.1037/11771-007

Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The brain's default network. *Annals of the New York Academy of Sciences*, *1124*(1), 1-38. doi: 10.1196/annals.1440.011

Caggiano, D. M., & Parasuraman, R. (2004). The role of memory representation in the vigilance decrement. *Psychonomic Bulletin & Review*, *11*, 932-937. http://dx.doi.org/10.3758/BF03196724

Carlson, L. E., & Garland, S. N. (2005). Impact of mindfulness-based stress reduction (MBSR) on sleep, mood, stress and fatigue symptoms in cancer outpatients. *International Journal of Behavioral Medicine*, *12*, 278-285. doi: 10.1207/s15327558ijbm1204_9

Carlson, L. E., Speca, M., Faris, P., & Patel, K. D. (2007). One year pre–post intervention follow-up of psychological, immune, endocrine and blood pressure outcomes of mindfulness-based stress reduction (MBSR) in breast and prostate cancer outpatients. *Brain, Behavior, and Immunity*, *21*, 1038-1049. doi: 10.1016/j.bbi.2007.04.002

Carmody, J., & Baer, R. A. (2009). How long does a mindfulness-based stress reduction program need to be? A review of class contact hours and effect sizes for psychological distress. *Journal of Clinical Psychology*, 65(6), 627-638. doi: 10.1002/jclp.20555.

Carver, C. S., & Connor-Smith, J. (2010). Personality and coping. *Annual Review of Psychology*, *61*, 679-704. doi: 10.1146/annurev.psych.093008.100352.

Chen, A. (2015, May 16th). Why Companies Are Promoting Mindfulness at the Office. *The Wall Street Journal*, Retrieved from wsj.com.

Chu, L. C. (2010). The benefits of meditation vis-à-vis emotional intelligence, perceived stress and negative mental health. *Stress and Health*, *26*, 169-180. doi: 10.1002/smi.1289

Chiesa, A., Calati, R., & Serretti, A. (2011). Does mindfulness training improve cognitive abilities? A systematic review of neuropsychological findings. *Clinical Psychology Review*, *31*, 449-464. doi: 10.1016/j.cpr.2010.11.003

Cox-Fuenzalida, L. E., Beeler, C., & Sohl, L. (2006). Workload history effects: A comparison of sudden increases and decreases on performance. *Current Psychology*, *25*, 8-14. doi: 10.1007/s12144-006-1012-6

Cox-Fuenzalida, L. E., Swickert, R., & Hittner, J. B. (2004). Effects of neuroticism and workload history on performance. *Personality and Individual Differences*, *36*, 447-456. https://doi.org/10.1016/S0191-8869(03)00108-9

Creswell, J. D. (2017). Mindfulness interventions. *Annual Review of Psychology*, *68*, 491-516. https://doi.org/10.1146/annurev-psych-042716-051139

Csikszentmihalyi, M., & Csikszentmihalyi, I. S. (Eds.). (1992). *Optimal Experience: Psychological Studies of Flow in Consciousness*. New York, NY: Cambridge University Press.

Dandeneau, S. D., Baldwin, M. W., Baccus, J. R., Sakellaropoulo, M., & Pruessner, J. C. (2007). Cutting stress off at the pass: Reducing vigilance and responsiveness to social threat by manipulating attention. *Journal of Personality and Social Psychology*, *93*, 651-666. doi: 10.1037/0022-3514.93.4.651

Davidson, R. J., Kabat-Zinn, J., Schumacher, J., Rosenkranz, M., Muller, D., Santorelli, S. F., & Sheridan, J. F. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine*, *65*, 564-570.

Davies, D. R., & Parasuraman, R. (1982). *The psychology of vigilance.* Academic Press.

Demerouti, E., Bakker, A. B., Nachreiner, F., & Schaufeli, W. B. (2001). The job demands-resources model of burnout. *Journal of Applied Psychology*, *86*, 499-512. doi: 10.1037/0021-9010.86.3.499

Demerouti, E., Bakker, A. B., Sonnentag, S., & Fullagar, C. J. (2012). Work-related flow and energy at work and at home: A study on the role of daily recovery. *Journal of Organizational Behavior*, *33*, 276-295. doi: 10.1002/job.760

Diamond, D. M., Fleshner, M., Ingersoll, N., & Rose, G. (1996). Psychological stress impairs spatial working memory: relevance to electrophysiological studies of hippocampal function. *Behavioral Neuroscience*, *110*, 661-672. http://dx.doi.org/10.1037/0735-7044.110.4.661

Drach-Zahavy, A., & Erez, M. (2002). Challenge versus threat effects on the goal-performance relationship. *Organizational Behavior and Human Decision Processes*, *88*, 667-682. http://dx.doi.org/10.1016/S0749-5978(02)00004-3

Dwyer, D. J., & Ganster, D. C. (1991). The effects of job demands and control on employee attendance and satisfaction. *Journal of Organizational Behavior*, *12*, 595-608. doi: 10.1002/job.4030120704

Eddy, M. D., Brunyé, T. T., Tower-Richardi, S., Mahoney, C. R., & Taylor, H. A. (2015). The effect of a brief mindfulness induction on processing of emotional images: an ERP study. *Frontiers in Psychology*, *6*, 1-12. doi: 10.3389/fpsyg.2015.01391

Epel, E., Daubenmier, J., Moskowitz, J. T., Folkman, S., & Blackburn, E. (2009). Can meditation slow rate of cellular aging? Cognitive stress, mindfulness, and telomeres. *Annals of the New York Academy of Sciences*, *1172*, 34-53. doi: 10.1111/j.1749-6632.2009.04414.x

Erisman, S. M., & Roemer, L. (2010). A preliminary investigation of the effects of experimentally induced mindfulness on emotional responding to film clips. *Emotion*, *10*, 72-82. doi: 10.1037/a0017162

Fagan, D., Swift, C. G., & Tiplady, B. (1988). Effects of caffeine on vigilance and other performance tests in normal subjects. *Journal of Psychopharmacology*, *2*, 19-25. doi: 10.1177/026988118800200104

Feldman, G., Greeson, J., & Senville, J. (2010). Differential effects of mindful breathing, progressive muscle relaxation, and loving-kindness meditation on decentering and negative reactions to repetitive thoughts. *Behaviour Research and Therapy*, *48*, 1002-1011. doi: 10.1016/j.brat.2010.06.006

Fenigstein, A., Scheier, M. F., & Buss, A. H. (1975). Public and private self-consciousness: Assessment and theory. *Journal of Consulting and Clinical Psychology*, *43*, 522-527. http://dx.doi.org/10.1037/h0076760

Finomore, V., Matthews, G., Shaw, T., & Warm, J. (2009). Predicting vigilance: A fresh look at an old problem. *Ergonomics*, *52*, 791-808. doi: 10.1080/00140130802641627

Fisk, A. D., & Schneider, W. (1981). Control and automatic processing during tasks requiring sustained attention: A new approach to vigilance. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *23*, 737-750. doi: 10.1177/001872088102300610

Folkman, S., & Moskowitz, J. T. (2004). Coping: Pitfalls and promise. *Annual Review of Psychology*, *55*, 745-774. https://doi.org/10.1146/annurev.psych.55.090902.141456

Fortney, L., Luchterhand, C., Zakletskaia, L., Zgierska, A., & Rakel, D. (2013). Abbreviated mindfulness intervention for job satisfaction, quality of life, and compassion in primary care clinicians: a pilot study. *The Annals of Family Medicine*, *11*, 412-420. doi: 10.1370/afm.1511.

Frankenhaeuser, M., Nordheden, B., Myrsten, A. L., & Post, B. (1971). Psychophysiological reactions to understimulation and overstimulation. *Acta Psychologica*, *35*, 298-308. http://dx.doi.org/10.1016/0001-6918(71)90038-2

Frewer, L. J., & Lader, M. (1991). The effects of caffeine on two computerized tests of attention and vigilance. *Human Psychopharmacology: Clinical and Experimental*, *6*, 119-128. doi: 10.1002/hup.470060206

Frewen, P. A., Dozois, D. J., Neufeld, R. W., Lane, R. D., Densmore, M., Stevens, T. K., & Lanius, R. A. (2010). Individual differences in trait mindfulness predict dorsomedial prefrontal and amygdala response during emotional imagery: An fMRI study. *Personality and Individual Differences*, *49*, 479-484. https://doi.org/10.1016/j.paid.2010.05.008

Gaab, J., Blättler, N., Menzi, T., Pabst, B., Stoyer, S., & Ehlert, U. (2003). Randomized controlled evaluation of the effects of cognitive–behavioral stress management on cortisol responses to acute stress in healthy subjects. Psychoneuroendocrinology, *28*, 767-779. doi:10.1016/S0306-4530(02)00069-0

Gelles, D. (2012). *Mindful work: How meditation is changing business from the inside out.* New York, NY: Houghton Mifflin Harcourt.

Golden, C. J., & Freshwater, S. M. (1978). *Stroop color and word test.* Chicago, IL: Stoelting Co.

Good, D. J., Lyddy, C. J., Glomb, T. M., Bono, J. E., Brown, K. W., Duffy, M. K., ... & Lazar, S. W. (2016). Contemplating Mindfulness at Work: An Integrative Review. *Journal of Management*, *42*, 114-142. doi: 10.1177/0149206315617003

Grégoire, S., & Lachance, L. (2014). Evaluation of a brief mindfulness-based intervention to reduce psychological distress in the workplace. *Mindfulness, 6,* 836-847. https://doi.org/10.1007/s12671-014-0328-9.

Grier, R. A., Warm, J. S., Dember, W. N., Matthews, G., Galinsky, T. L., Szalma, J. L., & Parasuraman, R. (2003). The vigilance decrement reflects limitations in effortful attention, not mindlessness. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *45*, 349-359. https://doi.org/10.1518/hfes.45.3.349.27253

Grossman, P., Niemann, L., Schmidt, S., & Walach, H. (2004). Mindfulness-based stress reduction and health benefits: A meta-analysis. *Journal of Psychosomatic Research*, *57*, 35-43. https://doi.org/10.1016/S0022-3999(03)00573-7

Hafenbrack, A. C., Kinias, Z., & Barsade, S. G. (2014). Debiasing the mind through meditation mindfulness and the sunk-cost bias. *Psychological Science*, *25*, 369-376. https://doi.org/10.1177/0956797613503853

Hancock, P. A., & Warm, J. S. (1989). A dynamic model of stress and sustained attention. *Human Factors*, *31*, 519–537. https://doi.org/10.1177/001872088903100503

Hart, S.G., & Staveland, L.E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P.A. Hancock & N. Meshkati (Eds.), *Advances in Psychology: Human Mental Workload*, (Vol. 52, pp. 139–

183), Oxford, England: North-Holland. http://dx.doi.org/10.1016/S0166-4115(08)62386-9

Hawley, J. K. (2006). Patriot fratricides: The human dimension lessons of Operation Iraqi Freedom. *Field Artillery, 11*, 18-19.

Hayes, A. F. (2018*). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: Guilford Publications.

Helton, W. S. (2004). Validation of a short stress state questionnaire. *In Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 48, pp. 1238-1242). Chicago, IL: SAGE Publications.https://doi.org/10.1177/154193120404801107

Helton, W. S., & Holmstrom, R. (2006, October). Cognitive slips-failures and daily stress: Further investigations with the Short Stress State Questionnaire-Daily (SSSQ-D). *In Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 50, pp. 1240-1244). Los Angeles, CA: Sage Publications.

Helton, W. S., & Russell, P. N. (2011). Working memory load and the vigilance decrement. *Experimental Brain Research*, *212*, 429-437. doi: 10.1007/s00221-011-2749-1

Helton, W. S., & Russell, P. N. (2012). Brief mental breaks and content-free cues may not keep you focused. *Experimental Brain Research, 219*, 37-46. doi: 10.1007/s00221-012-3065-0

Helton, W. S., Shaw, T., Warm, J. S., Matthews, G., & Hancock, P. (2008). Effects of warned and unwarned demand transitions on vigilance performance and stress. *Anxiety, Stress, & Coping*, *21*, 173-184. doi: 10.1080/10615800801911305

Helton, W. S., & Warm, J. S. (2008). Signal salience and the mindlessness theory of vigilance. *Acta Psychologica*, *129*, 18-25. doi: 10.1016/j.actpsy.2008.04.002

Helton, W. S., Warm, J. S., Mathews, G., Corcoran, K., & Dember, W. N. (2002). Further tests of the abbreviated vigil: Effects of signal salience and noise on performance and stress. *Proceedings of the Human Factors and Ergonomics Society*, *46*, 1546–1550. https://doi.org/10.1177/154193120204601704

Hitchcock, E. M., Dember, W. N., Warm, J. S., Moroney, B. W., & See, J. E. (1999). Effects of cueing and knowledge of results on workload and boredom in sustained attention. Human Factors: *The Journal of the Human Factors and Ergonomics Society*, *41*, 365-372. https://doi.org/10.1518/001872099779610987

Hitchcock, E. M., Warm, J. S., Matthews, G., Dember, W. N., Shear, P. K., Tripp, L. D. & Parasuraman, R. (2003). Automation cueing modulates cerebral blood flow and vigilance in a simulated air traffic control task. *Theoretical Issues in Ergonomics Science*, *4*, 89-112. https://doi.org/10.1080/14639220210159726

Hollis-Walker, L., & Colosimo, K. (2011). Mindfulness, self-compassion, and happiness in non-meditators: A theoretical and empirical examination. *Personality and Individual Differences*, *50*, 222-227. https://doi.org/10.1016/j.paid.2010.09.033

Hölzel, B. K., Carmody, J., Evans, K. C., Hoge, E. A., Dusek, J. A., Morgan, L., ... & Lazar, S. W. (2009). Stress reduction correlates with structural changes in the amygdala. *Social Cognitive and Affective Neuroscience*, *5*, 11-17. https://doi.org/10.1093/scan/nsp034

Hölzel, B. K., Carmody, J., Vangel, M., Congleton, C., Yerramsetti, S. M., Gard, T., & Lazar, S. W. (2011). Mindfulness practice leads to increases in regional brain gray matter density. *Psychiatry Research: Neuroimaging*, *191*, 36-43. doi: 10.1016/j.pscychresns.2010.08.006

Huber, K. E., Hill, S. E., & Merritt, S. M. (2015). Minding the Gap: Extending Mindfulness to Safety-Critical Occupations. *Industrial and Organizational Psychology*, *8*, 699-705. https://doi.org/10.1017/iop.2015.103

Hülsheger, U. R., Alberts, H. J., Feinholdt, A., & Lang, J. W. (2013). Benefits of mindfulness at work: the role of mindfulness in emotion regulation, emotional exhaustion, and job satisfaction. *Journal of Applied Psychology*, *98*, 310-325. doi: 10.1037/a0031313

Hülsheger, U. R., Lang, J. W., Depenbrock, F., Fehrmann, C., Zijlstra, F. R., & Alberts, H. J. (2014). The power of presence: The role of mindfulness at work for daily levels and change trajectories of psychological detachment and sleep quality. *Journal of Applied Psychology*, *99*, 1113-1128. doi: 10.1037/a0037702.

Hülsheger, U. R., Feinholdt, A., & Nübold, A. (2015). A low-dose mindfulness intervention and recovery from work: Effects on psychological detachment, sleep quality, and sleep duration. *Journal of Occupational and Organizational Psychology*, *88*, 464-489. doi: 10.1111/joop.12115

Hyland, P. K., Lee, R. A., & Mills, M. J. (2015). Mindfulness at work: A new approach to improving individual and organizational performance. *Industrial and Organizational Psychology*, *8*, 576-602. https://doi.org/10.1017/iop.2015.41

Jain, S., Shapiro, S. L., Swanick, S., Roesch, S. C., Mills, P. J., Bell, I., & Schwartz, G. E. (2007). A randomized controlled trial of mindfulness meditation versus relaxation training: effects on distress, positive states of mind, rumination, and distraction.

Annals of Behavioral Medicine, *33*, 11-21. https://doi.org/10.1207/s15324796abm3301_2

Jamieson, J. P., Mendes, W. B., & Nock, M. K. (2013). Improving acute stress responses the power of reappraisal. *Current Directions in Psychological Science*, *22*, 51-56. https://doi.org/10.1177/0963721412461500

Jensen CG, Vangkilde S, Frokjaer V, Hasselbalch SG. 2012. Mindfulness training affects attention—Or is it attentional effort? *Journal of Experimental Psychology: General*. *141*,106-123. doi: 10.1037/a0024931

Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion*. *10*, 54-64. doi: 10.1037/a0018438

Johns, M. W. (1991). A new method for measuring daytime sleepiness: The Epworth Sleepiness Scale. *Sleep*, *14*, 540–545. https://doi.org/10.1093/sleep/14.6.540

Jones, D. L. (2013). *Mindfulness meditation: Effect of a brief intervention on cardiovascular reactivity during acute stress*. (Master's thesis). Retrieved from BYU ScholarsArchive.

Kabat-Zinn, J. (1982). An outpatient program in behavioral medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, *4*, 33–47.

Kabat-Zinn, J. (1990). *Full catastrophe living: Using the wisdom of your body and mind to face stress, pain, and illness*. New York, NY: Dell Publishing.

Kabat-Zinn, J. (2003). Mindfulness-based interventions in context: past, present, and future. *Clinical Psychology: Science and Practice, 10,* 144-156. doi: 10.1093/clipsy.bpg016

Kabat-Zinn, J. (2005). *Coming to our senses: Healing ourselves and the world through mindfulness*. United Kingdom: Hachette Books.

Keil, A., & Ihssen, N. (2004). Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion, 4,* 23-35.

Kelly, C. (2012, April 28). O.K., Google, Take a Deep Breath. *The New York Times,* Retrieved from http://www.nytimes.com.

Kiken, L. G., Garland, E. L., Bluth, K., Palsson, O. S., & Gaylord, S. A. (2015). From a state to a trait: trajectories of state mindfulness in meditation during intervention predict changes in trait mindfulness. *Personality and Individual Differences*, *81*, 41-46. https://doi.org/10.1016/j.paid.2014.12.044

Klatt, M. D., Buckworth, J., & Malarkey, W. B. (2009). Effects of Low-Dose Mindfulness-Based Stress Reduction (MBSR-ld) on Working Adults. *Health Education & Behavior*, *36,* 601-614. doi: 10.1177/1090198108317627

Kline, T. J. (2005). *Psychological testing: A practical approach to design and evaluation*. Thousand Oaks, CA: Sage Publications.

Kribbs, N. B., & Dinges, D. (1994). Vigilance decrement and sleepiness. In R. D. Ogilvie & J. R. Harsh (Eds.), *Sleep onset: Normal and abnormal processes* (Vol. 1, pp. 113-125). Washington, D.C.: American Psychological Association. http://dx.doi.org/10.1037/10166-007

Lane, J. D., & Phillips-Bute, B. G. (1998). Caffeine deprivation affects vigilance performance and mood. *Physiology & Behavior*, *65*, 171-175. doi: 10.1016/S0031-9384(98)00163-2

Larson, M. J., Steffen, P. R., & Primosch, M. (2012). The impact of a brief mindfulness meditation intervention on cognitive control and error-related performance monitoring. *Frontiers in Human Neuroscience*, *7*, 308-308. doi: 10.3389/fnhum.2013.00308

Lazarus, R. S., & Folkman, S. (1984). Coping and adaptation. In W. D. Gentry (Ed.). *The Handbook of Behavioral Medicine* (Vol. 6, pp. 282- 325). New York, NY: Guilford.

Lieberman, H. R., Tharion, W. J., Shukitt-Hale, B., Speckman, K. L., & Tulley, R. (2002). Effects of caffeine, sleep loss, and stress on cognitive performance and mood during US Navy SEAL training. *Psychopharmacology*, *164*, 250-261. doi:10.1007/s00213-002-1217-9

Lim, J., Quevenco, F. C., & Kwok, K. (2013). EEG alpha activity is associated with individual differences in post-break improvement. *Neuroimage*, *76*, 81-89. doi: 10.1016/j.neuroimage.2013.03.018

Lim, J., Wu, W. C., Wang, J., Detre, J. A., Dinges, D. F., & Rao, H. (2010). Imaging brain fatigue from sustained mental workload: an ASL perfusion study of the time-on-task effect. *Neuroimage*, *49*, 3426-3435. doi: 10.1016/j.neuroimage.2009.11.020

Liu, X., Wang, S., Chang, S., Chen, W., & Si, M. (2013). Effect of brief mindfulness intervention on tolerance and distress of pain induced by cold-pressor task. *Stress and Health*, *29*, 199-204. doi: 10.1002/smi.2446

Long, E. C., & Christian, M. S. (2015). Mindfulness buffers retaliatory responses to injustice: A regulatory approach. *Journal of Applied Psychology*, *100*, 1409-1422. doi: DOI: 10.1037/apl0000019

Lutz, A., Greischar, L. L., Rawlings, N. B., Ricard, M., & Davidson, R. J. (2004). Long-term meditators self-induce high-amplitude gamma synchrony during mental practice. *Proceedings of the National Academy of Sciences of the United States of America*, *101*, 16369-16373. https://doi.org/10.1073/pnas.0407401101

Mackie, R. R. (1987). Vigilance research—are we ready for countermeasures?. Human Factors: *The Journal of the Human Factors and Ergonomics Society*, *29*, 707-723. https://doi.org/10.1177/001872088702900610

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: an integrative review. *Psychological Bulletin*, *109*, 163-203. doi: 10.1037/0033-2909.109.2.163

Mackworth, N. H. (1948). The breakdown of vigilance during prolonged visual search. *Quarterly Journal of Experimental Psychology*, *1*, 6-21. https://doi.org/10.1080/17470214808416738

Mason, M. F., Norton, M. I., Van Horn, J. D., Wegner, D. M., Grafton, S. T., & Macrae, C. N. (2007). Wandering minds: the default network and stimulus-independent thought. *Science*, *315*, 393-395. doi: 10.1126/science.1131295

McCarley, J. S., Kramer, A. F., Wickens, C. D., Vidoni, E. D., & Boot, W. R. (2004). Visual skills in airport-security screening. *Psychological Science, 15*, 302-306. https://doi.org/10.1111/j.0956-7976.2004.00673.x

McHugh, L., Simpson, A., & Reed, P. (2010). Mindfulness as a potential intervention for stimulus over-selectivity in older adults. *Research in Developmental Disabilities, 31*, 178-184. doi: 10.1016/j.ridd.2009.08.009

McIntyre, J. W. (1985). Ergonomics: Anesthetists' use of auditory alarms in the operating room. *International Journal of Clinical Monitoring and Computing*, *2*, 47-55.

Merritt, S. M. (2011). Affective processes in human–automation interactions. Human Factors: *The Journal of the Human Factors and Ergonomics Society*, *53*, 356-370. https://doi.org/10.1177/0018720811411912

Merritt, S. M., & Ilgen, D. R. (2008). Not all trust is created equal: Dispositional and history-based trust in human-automation interactions. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *50*, 194-210. doi: 10.1518/001872008X288574

Miceli, M., & Castelfranchi, C. (2005). Anxiety as an "epistemic" emotion: An uncertainty theory of anxiety. *Anxiety, Stress, and Coping*, *18*, 291-319. https://doi.org/10.1080/10615800500209324

Molloy, R., & Parasuraman, R. (1996). Monitoring an automated system for a single failure: Vigilance and task complexity effects. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *38*, 311-322. https://doi.org/10.1177/001872089606380211

Mrazek, M. D., Smallwood, J., & Schooler, J. W. (2012). Mindfulness and mind-wandering: finding convergence through opposing constructs. *Emotion*, *12*, 442-448. doi: 10.1037/a0026678

Narayanan, J., & Moynihan, L. 2006. Mindfulness at work: The beneficial effects on job burnout in call centers. *Academy of Management Best Conference Paper*, OB: H1.

Nickerson, R. S. (1992). What Does Human Factors Research Have to Do with Environmental Management?. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 36, pp. 636-639). Los Angeles, CA: SAGE Publications.

Nielsen, L., & Kaszniak, A. W. (2006). Awareness of subtle emotional feelings: a comparison of long-term meditators and nonmeditators. *Emotion*, *6*, 392-405. doi: 10.1037/1528-3542.6.3.392

Nuechterlein, K. H., Parasuraman, R., & Jiang, Q. (1983). Visual sustained attention: Image degradation produces rapid sensitivity decrement over time. *Science*, *220*, 327-329.

Oei, N. Y. L., Everaerd, W. T. A. M., Elzinga, B. M., Van Well, S., & Bermond, B. (2006). Psychosocial stress impairs working memory at high loads: an association with cortisol levels and memory retrieval. *Stress*, *9*, 133-141. doi: 10.1080/10253890600965773

O'Hanlon, J. F. (1965). Adrenaline and noradrenaline: Relation to performance in a visual vigilance task. *Science*, *150*, 507-509. doi: 10.1126/science.150.3695.507

Ong, J., & Sholtes, D. (2010). A mindfulness-based approach to the treatment of insomnia. *Journal of Clinical Psychology*, *66*, 1175-1184. doi: 10.1002/jclp.20736

Papies, E. K., Pronk, T. M., Keesman, M., & Barsalou, L. W. (2015). The benefits of simply observing: Mindful attention modulates the link between motivation and behavior. *Journal of Personality and Social Psychology*, *108*, 148-170. doi: 10.1037/a0038032

Parasuraman, R. (1979). Memory load and event rate control sensitivity decrements in sustained attention. *Science*, *205*, 924-927.

Parasuraman, R. (1986). Vigilance, monitoring and search. In K. R. Boff, L. Kaufman, & J. P. Thomas (Eds.), *Handbook of human perception and performance. (*Vol. II, pp. 41-49). New York, NY: Wiley

Parasuraman, R. (2011). Neuroergonomics brain, cognition, and performance at work. *Current Directions in Psychological Science*, *20*, 181-186. https://doi.org/10.1177/0963721411409176

Parasuraman, R., & Davies, D. R. (1977). A taxonomic analysis of vigilance. In R. R. Mackie (Ed.), *Vigilance: Theory, operational performance, and physiological correlates* (pp. 559–574). New York, NY: Plenum.

Parasuraman, R., & Giambra, L. (1991). Skill development in vigilance: effects of event rate and age. *Psychology and Aging*, *6*, 155-169. http://dx.doi.org/10.1037/0882-7974.6.2.155

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *39*, 230-253. https://doi.org/10.1518/001872097778543886

Parasuraman, R., Warm, J. S., & Dember, W. N. (1987). Vigilance: Taxonomy and utility. In L. S. Mark, J. S.Warm, & R. L. Huston (Eds.), *Ergonomics and human factors: Recent research* (pp. 11–32). New York, NY: Springer-Verlag.

Poulin, P. A., Mackenzie, C. S., Soloway, G., & Karayolas, E. (2008). Mindfulness training as an evidenced-based approach to reducing stress and promoting well-being among human services professionals. *International Journal of Health Promotion and Education*, *46*, 72-80. https://doi.org/10.1080/14635240.2008.10708132

O'Hanlon, J. F. (1965). Adrenaline and noradrenaline: Relation to performance in a visual vigilance task. Science, *150*, 507-509. doi: 10.1126/science.150.3695.507

Querstret, D., & Cropley, M. (2012). Exploring the relationship between work-related rumination, sleep quality, and work-related fatigue. *Journal of Occupational Health Psychology*, *17*, 341-353. doi: 10.1037/a0028552

Querstret, D., Cropley, M., & Fife-Schaw, C. (2016). Internet-based instructor-led mindfulness for work-related rumination, fatigue and sleep: assessing facets of mindfulness as mechanisms of change. A randomised waitlist control trial. *Journal of Occupational Health*, *22*, 153-169. http://dx.doi.org/10.1037/ocp0000028

Reason, P. (1993). Reflections on sacred experience and sacred science. *Journal of Management Inquiry*, *2*, 273-283. https://doi.org/10.1177/105649269323009

Reason, J., & Lucas, D. (1984). Absent-mindedness in shops: Its incidence, correlates and consequences. *British Journal of Clinical Psychology, 23*, 121-131. https://doi.org/10.1111/j.2044-8260.1984.tb00635.x

Reb, J., & Narayanan, J. (2014). The influence of mindful attention on value claiming in distributive negotiations: Evidence from four laboratory experiments. *Mindfulness*, *5*, 756-766. https://doi.org/10.1007/s12671-013-0232-8

Reid, D. (2011). Mindfulness and flow in occupational engagement: Presence in doing. Canadian *Journal of Occupational Therapy, 78,* 50-56. https://doi.org/10.2182/cjot.2011.78.1.7

Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). “Oops!”: Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia*, *35*, 747-758. https://doi.org/10.1016/S0028-3932(97)00015-8

Rosenzweig, S., Reibel, D. K., Greeson, J. M., Brainard, G. C., & Hojat, M. (2003). Mindfulness-based stress reduction lowers psychological distress in medical students. *Teaching and Learning in Medicine, 15*, 88-92. doi: 10.1207/S15328015TLM1502_03

Ross, H. A., Russell, P. N., & Helton, W. S. (2014). Effects of breaks and goal switches on the vigilance decrement. *Experimental Brain Research*, *232*, 1729-1737. doi: 10.1007/s00221-014-3865-5

Roth, T. (2007). Insomnia: definition, prevalence, etiology, and consequences. *Journal of Clinical Sleep Medicine, 3*, S7-S10.

Roth, S., & Cohen, L. J. (1986). Approach, avoidance, and coping with stress. *American Psychologist*, *41*, 813-819. http://dx.doi.org/10.1037/0003-066X.41.7.813

Ruedy, N. E., & Schweitzer, M. E. (2010). In the moment: The effect of mindfulness on ethical decision making. *Journal of Business Ethics*, *95*, 73-87. https://doi.org/10.1007/s10551-011-0796-y

Sackett, P. R., Zedeck, S., & Fogli, L. (1988). Relations between measures of typical and maximum job performance. *Journal of Applied Psychology*, *73*, 482-486. doi: 10.1037/0021-9010.73.3.482

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research*, *99*, 323-338. https://doi.org/10.3200/JOER.99.6.323-338

Schwid, S. R., Tyler, C. M., Scheid, E. A., Weinstein, A., Goodman, A. D., & McDermott, M. P. (2003). Cognitive fatigue during a test requiring sustained attention: a pilot study. *Multiple Sclerosis*, *9*, 503-508. doi: 10.1191/1352458503ms946oa

See, J. E., Howe, S. R., Warm, J. S., & Dember, W. N. (1995). A meta-analysis of the sensitivity decrement in vigilance. *Psychological Bulletin*, *117*, 230–249. doi: 10.1037/0033-2909.117.2.230

Shackman, A. J., Sarinopoulos, I., Maxwell, J. S., Pizzagalli, D. A., Lavric, A., & Davidson, R. J. (2006). Anxiety selectively disrupts visuospatial working memory. *Emotion*, *6*, 40-61. doi: 10.1037/1528-3542.6.1.40

Shapiro, S. L., Astin, J. A., Bishop, S. R., & Cordova, M. (2005). Mindfulness-based stress reduction for health care professionals: results from a randomized trial. *International Journal of Stress Management*, *12*, 164-176. http://dx.doi.org/10.1037/1072-5245.12.2.164

Shapiro, S. L., Brown, K. W., & Biegel, G. M. (2007). Teaching self-care to caregivers: effects of mindfulness-based stress reduction on the mental health of therapists in training. *Training and Education in Professional Psychology*, *1*, 105-115. doi: 10.1037/1931-3918.1.2.105

Shaw, T. H., Matthews, G., Warm, J. S., Finomore, V. S., Silverman, L., & Costa, P. T. (2010). Individual differences in vigilance: Personality, ability and states of stress. *Journal of Research in Personality*, *44*, 297-308. doi: 10.1016/j.jrp.2010.02.007

Smit, A. S., Eling, P. A., & Coenen, A. M. (2004). Mental effort causes vigilance decrease due to resource depletion. *Acta Psychologica*, *115*, 35-42. doi: 10.1016/j.actpsy.2003.11.001

Stanislaw, H., & Todorov, N. (1999). Calculation of signal detection theory measures. *Behavior Research Methods, Instruments, & Computers*, *31*, 137-149. https://doi.org/10.3758/BF03207704

Sonnentag, S., Binnewies, C., & Mojza, E. J. (2008). " Did you have a nice evening?" A day-level study on recovery experiences, sleep, and affect. *Journal of Applied Psychology*, *93*, 674-684. http://dx.doi.org/10.1037/0021-9010.93.3.674

Steffen, P. R., & Larson, M. J. (2014). A Brief Mindfulness Exercise Reduces Cardiovascular Reactivity During a Laboratory Stressor Paradigm. *Mindfulness, 4* 803-811. doi: 10.1007/s12671-014-0320-4

Steffen, P. R., & Larson, M. J. (2015). A brief mindfulness exercise reduces cardiovascular reactivity during a laboratory stressor paradigm. *Mindfulness, 6*, 803-811. doi: 10.1007/s12671-014-0320-4

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643-662. http://dx.doi.org/10.1037/h0054651

Szalma, J. L., & Hancock, P. A. (2010, September). A Meta-Analytic Review of the Effects of Noise on Performance: Moderating Effects of Task and Noise Characteristics. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 54, pp. 1660-1664). SAGE Publications.

Szalma, J. L. (2011). Workload and stress in vigilance: The impact of display format and task type. *The American Journal of Psychology*, *124*, 441-454. doi: 10.5406/amerjpsyc.124.4.0441

Szalma, J. L., Warm, J. S., Matthews, G., Dember, W. N., Wiler, E. M., Meier, A., et al. (2004). Effects of sensory modality and task duration on performance, workload, and stress in sustained attention. *Human Factors*, *46*, 219–233. doi: 10.1518/hfes.46.2.219.37334

Tang, Y. Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, *16*, 213-225. doi: 10.1038/nrn3916

Tang, Y. Y., Ma, Y., Wang, J., Fan, Y., Feng, S., Lu, Q., ... & Posner, M. I. (2007). Short-term meditation training improves attention and self-regulation.

Proceedings of the National Academy of Sciences, *104*, 17152-17156. https://doi.org/10.1073/pnas.0707678104

Taylor, V. A., Grant, J., Daneault, V., Scavone, G., Breton, E., Roffe-Vidal, S., & ... Beauregard, M. (2011). Impact of mindfulness on the neural responses to emotional pictures in experienced and beginner meditators. *Neuroimage*, *57*, 1524-1533. doi: 10.1016/j.neuroimage.2011.06.001

Teichner, W. H. (1974). The detection of a simple visual signal as a function of time of watch. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *16*, 339-352. https://doi.org/10.1177/001872087401600402

Temple, J. G., Warm, J. S., Dember, W. N., Jones, K. S., LaGrange, C. M., & Matthews, G. (2000). The effects of signal salience and caffeine on performance, workload, and stress in an abbreviated vigilance task. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *42*, 183-194. doi: 10.1518/001872000779656480

Thiffault, P., & Bergeron, J. (2003). Fatigue and individual differences in monotonous simulated driving. *Personality and Individual Differences*, *34*, 159-176. doi: 10.1016/S0191-8869(02)00119-8

Trougakos, J. P., Beal, D. J., Green, S. G., & Weiss, H. M. (2008). Making the break count: An episodic examination of recovery activities, emotional experiences, and positive affective displays. *Academy of Management Journal*, *51*, 131-146. doi: 10.5465/AMJ.2008.30764063

Trougakos, J. P., Hideg, I., & Cheng, B. H. (2011). Lunch Breaks Unpacked: The Effect of Daily Lunch Break Activities and Control Over Break on Fatigue. In Academy of Management Proceedings (Vol. 2011, pp. 1-6). Academy of Management. doi: 10.5465/AMBPP.2011.65869981

U.S. Department of Transportation, Federal Aviation Administration. (2012). *Evaluating the Effectiveness of Schedule Changes for Air Traffic Service (ATS) Providers: Controller Alertness and Fatigue Monitoring Study* (No. DOT/FAA/HFD-13/001). Washington, DC: Orasanu, J., Parke, B., Kraft, N., Tada, Y., Hobbs, A., Anderson, B., ... & Dulchinos, V.

van den Hurk, P. A., Giommi, F., Gielen, S. C., Speckens, A. E., & Barendregt, H. P. (2010). Greater efficiency in attentional processing related to mindfulness meditation. *The Quarterly Journal of Experimental Psychology*, *63*, 1168-1180. https://doi.org/10.1080/17470210903249365

Walach, H., Buchheld, N., Buttenmüller, V., Kleinknecht, N., & Schmidt, S. (2006). Measuring mindfulness—the Freiburg mindfulness inventory (FMI). *Personality and Individual Differences, 40*, 1543-1555. https://doi.org/10.1016/j.paid.2005.11.025

Warm, J. S. (1993). Vigilance and target detection. In C. D. Wickens & B.M. Huey (Eds.), *Workload transition: Implications for individual and team performance* (Vol 1., pp. 139–170). Washington, DC: National Research Council. https://doi.org/10.17226/2045

Warm, J. S., & Dember, W. N. (1998). Tests of vigilance taxonomy. In R. R. Hoffman, M. F. Sherrick, & J. S. Warm (Eds.), *Viewing psychology as a whole: The integrative science of William N. Dember* (pp. 87–112). Washington, DC: American Psychological Association.

Warm, J. S., Dember, W. N., & Hancock, P. A. (1996). Vigilance and workload in automated systems. In R. Parasuraman & M. Mouloua (Eds.), *Automation and human performance: Theory and applications* (1st Ed., pp. 183–200). Mahwah, NJ: Erlbaum.

Warm, J. S., & Jerision, H. J. (1984). The psychophysics of vigilance. In J.S. Warm (Ed.), *Sustained attention in human performance.* (1st Ed., pp. 15-59). Chichester, United Kingdom: Wiley.

Warm, J. S., Matthews, G., & Finomore, V. S. (2008). Workload and stress in sustained attention. In P. A. Hancock & J. L. Szalma (Eds.), Performance under stress (pp. 115–141). Aldershot, England: Ashgate Publishing.

Warm, J. S., Parasuraman, R., & Matthews, G. (2008). Vigilance requires hard mental work and is stressful. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *50*, 433-441. https://doi.org/10.1518/001872008X312152

Weinstein, N., Brown, K. W., & Ryan, R. M. (2009). A multi-method examination of the effects of mindfulness on stress attribution, coping, and emotional well-being. *Journal of Research in Personality*, *43*, 374-385. doi: 10.1016/j.jrp.2008.12.008

Wells, A. (2002). GAD, Meta-cognition, and Mindfulness: An Information Processing Analysis. *Clinical Psychology: Science and Practice*, *9*, 95-100. https://doi.org/10.1093/clipsy.9.1.95

Williamson, A., Lombardi, D. A., Folkard, S., Stutts, J., Courtney, T. K., & Connor, J. L. (2011). The link between fatigue and safety. *Accident Analysis & Prevention*, *43*, 498-515. doi: 10.1016/j.aap.2009.11.011

Winning, A. P., & Boag, S. (2015). Does brief mindfulness training increase empathy? The role of personality. *Personality and Individual Differences*, *86,* 492-498. doi: 10.1016/j.paid.2015.07.011

Wolever, R. Q., Bobinet, K. J., McCabe, K., Mackenzie, E. R., Fekete, E., Kusnick, C. A., & Baime, M. (2012). Effective and viable mind-body stress reduction in the workplace: a randomized controlled trial. *Journal of Occupational Health Psychology, 17*, 246-258. doi: 10.1037/a0027278

Valente, M. J., & MacKinnon, D. P. (2017). Comparing models of change to estimate the mediated effect in the pretest–posttest control group design. *Structural Equation Modeling: A Multidisciplinary Journal*, *24,* 428-450. https://doi.org/10.1080/10705511.2016.1274657

Valentine, E. R., & Sweet, P. L. (1999). Meditation and attention: A comparison of the effects of concentrative and mindfulness meditation on sustained attention. *Mental Health, Religion & Culture*, *2,* 59-70. https://doi.org/10.1080/13674679908406332

van den Hurk, P. A., Janssen, B. H., Giommi, F., Barendregt, H. P., & Gielen, S. C. (2010). Mindfulness meditation associated with alterations in bottom-up processing: psychophysiological evidence for reduced reactivity. *International Journal of Psychophysiology*, 78, 151-157. doi: 10.1016/j.ijpsycho.2010.07.002

Zeidan, F., Johnson, S. K., Diamond, B. J., David, Z., & Goolkasian, P. (2010). Mindfulness meditation improves cognition: evidence of brief mental training. *Consciousness and Cognition*, *19,* 597-605. doi: 10.1016/j.concog.2010.03.014

Zhang, J., Ding, W., Li, Y., & Wu, C. (2013). Task complexity matters: The influence of trait mindfulness on task and safety performance of nuclear power plant operators. *Personality and Individual Differences*, *55*, 433-439. http://dx.doi.org/10.1016/j.paid.2013.04.004

Zhang, J., & Wu, C. (2014). The influence of dispositional mindfulness on safety behaviors: A dual process perspective. *Accident Analysis & Prevention*, *70:* 24-32. doi: 10.1016/j.aap.2014.03.006

Appendix A

Tables and Figures

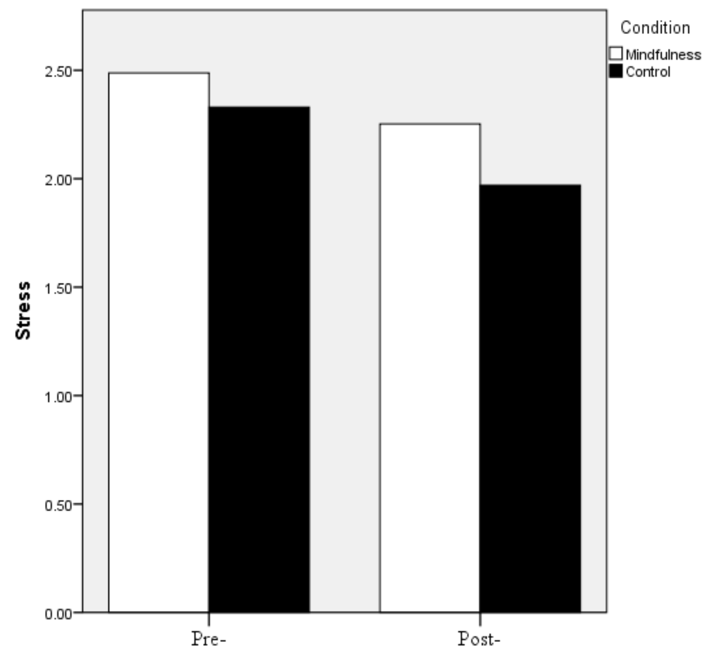


Figure 6. Average stress by condition pre- and post-manipulation

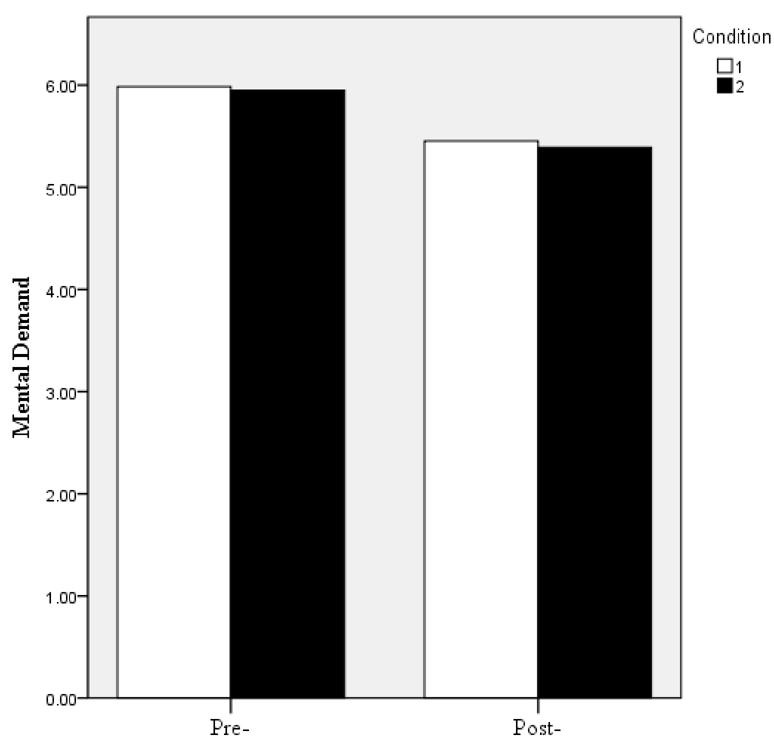


Figure 7. Average mental demand by condition pre- and post-manipulation

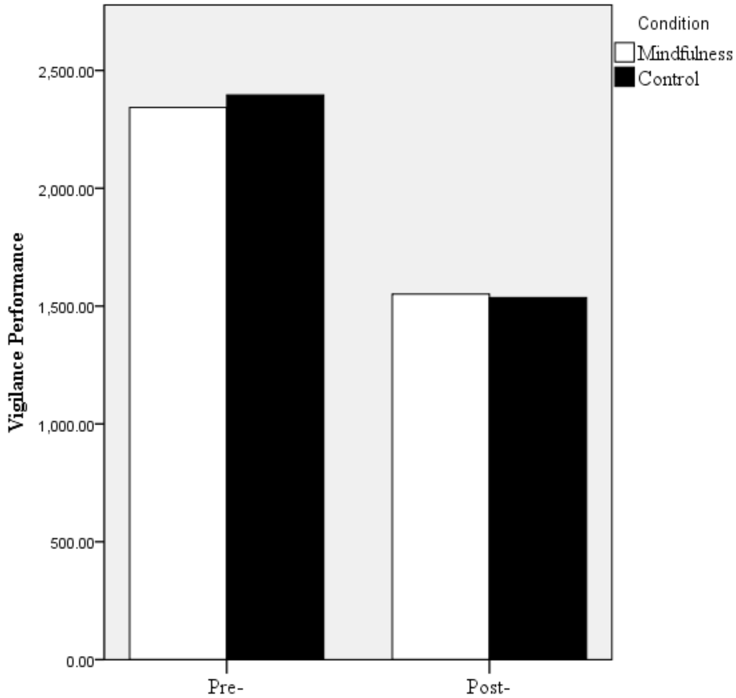


Figure 8. Average vigilance performance by condition pre- and post-manipulation

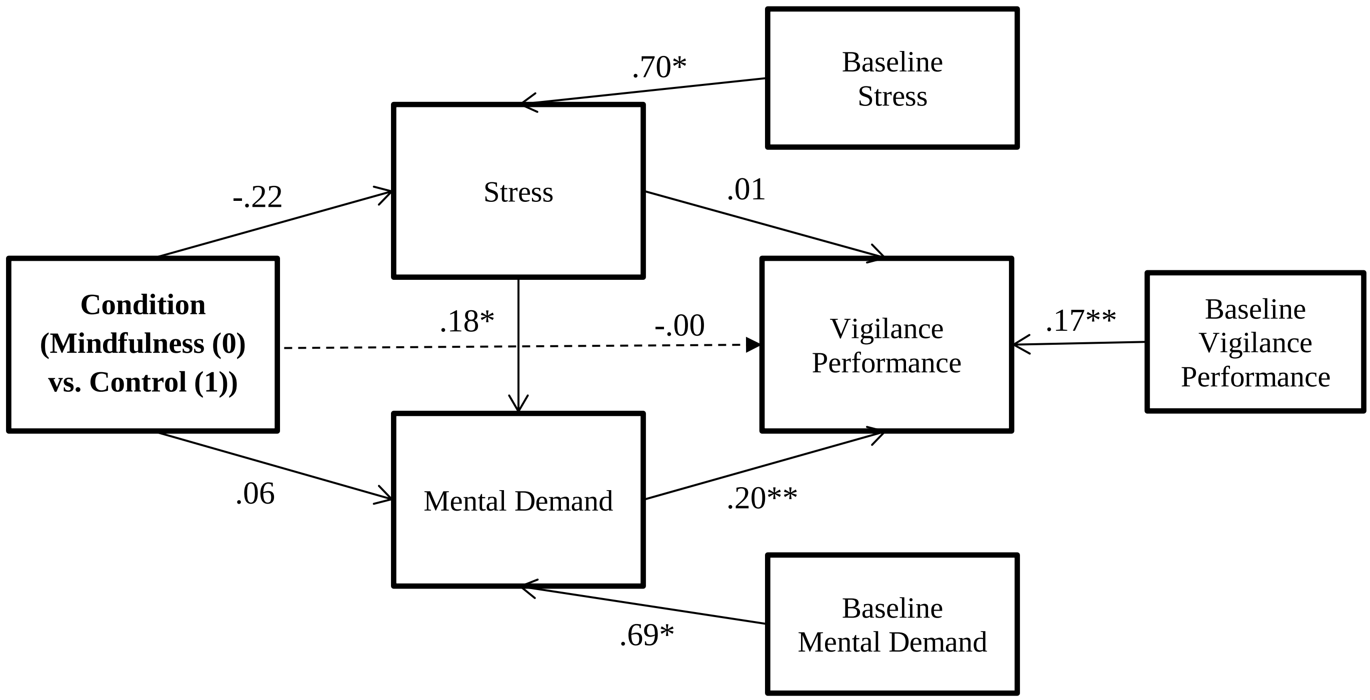


Figure 9. Hypothesized Sequential Mediation Model. *p<.05; **p<.10. Standardized regression coefficients are shown. Baseline measures were entered as covariates.

Table 2

Hypothesized Sequential Mediation Model – Unstandardized Bootstrapped Estimates and Associated 95% Confidence Intervals

Path Estimated	Indirect effect	SE	CI (LL)	CI (UP)
(H4) Cond.→ Stress → Vig. Perf. (a_1* b_1)	-2.01	38.23	-76.87	85.53
(H6) Cond.→ Ment. Demand → Vig. Perf. (a_2* b_2)	15.53	46.54	-62.16	132.37
(H7) Cond.→ Stress → Ment. Demand →Vig Perf. (a_1*a_3*b_2)	-10.97	11.46	-39.06	104.64

Note. SE = Standard Error; CI = confidence interval; LL = lower limit; UL = upper limit.

Table 3

Means, Standard Deviations, and Correlations among Time 1 and Time 2 Study Variables

	Variable	*M*	*SD*	1	2	3	4	5	6	7
1	Condition			-						
2	Stress (T1)	2.41	.756	-.11	(.77)					
3	Stress (T2)	2.12	.776	-.19	.71*	(.83)				
4	Mental Demand (T1)	5.97	1.73	-.01	.31*	.24*	(.77)			
5	Mental Demand (T2)	5.42	1.79	-.02	.20*	.34*	.73*	(.75)		
6	Vigilance Performance (T1)	2369.31	1366.88	.02	-.03	-.05	.13	.15	-	
7	Vigilance Performance (T2)	1543.56	1431.53	-.01	.03	.07	.12	.23*	.20*	-

Note. T1 = Time 1; T2 = Time 2; Time 2 variables are core to hypotheses; Time 1 variables are controlled as covariates. Scale reliabilities are shown on the diagonal. *$p < .05$.

Table 4

Correlations among Time 1 and Time 2 Study Variables by Condition

	Variable	1	2	3	4	5	6
1	Stress (T1)	1.00	.73**	.36*	.26**	-.02	.27**
2	Stress (T2)	.68*	1.00	.22	.28*	-.02	.17
3	Mental Demand (T1)	.26**	.26**	1.00	.77**	.15	.29*
4	Mental Demand (T2)	.14	.40*	.68*	1.00	.25**	.34*
5	Vigilance Performance (T1)	-.03	-.07	.12	.03	1.00	.23
6	Vigilance Performance (T2)	-.26**	-.04	-.08	.08	.17	1.00

Note. T1 = Time 1; T2 = Time 2; Time 2 variables are core to hypotheses; Time 1 variables are controlled as covariates. Condition 1 (Mindfulness) correlations are below the diagonal; Condition 2 (Control) correlations are above the diagonal. *$p < .05$; **$p < .10$

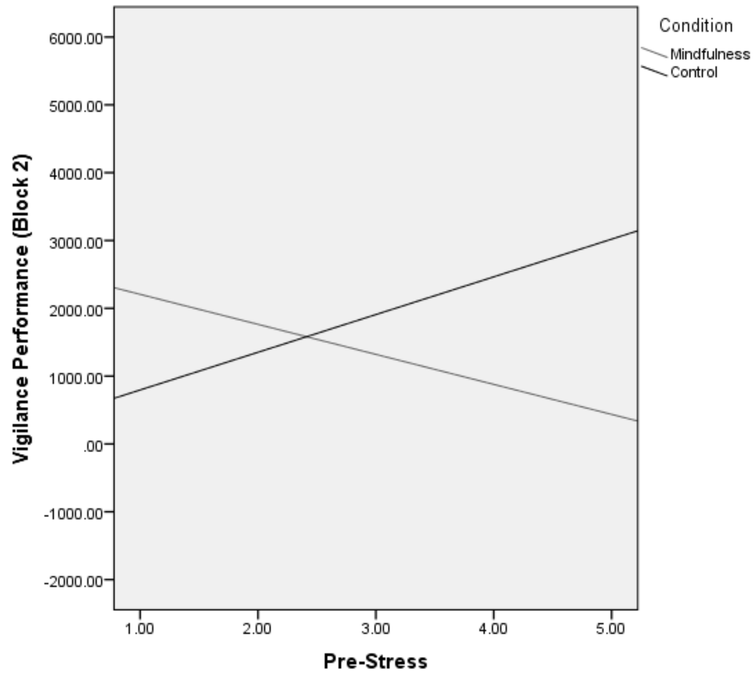


Figure 10. Relationship between pre-stress and vigilance performance moderated by condition

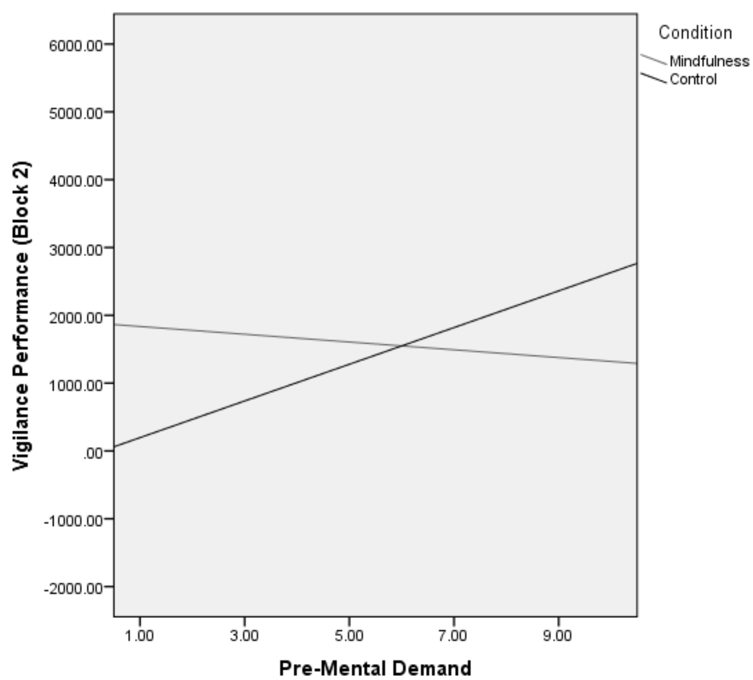


Figure 11. Relationship between pre-mental demand and vigilance performance moderated by condition

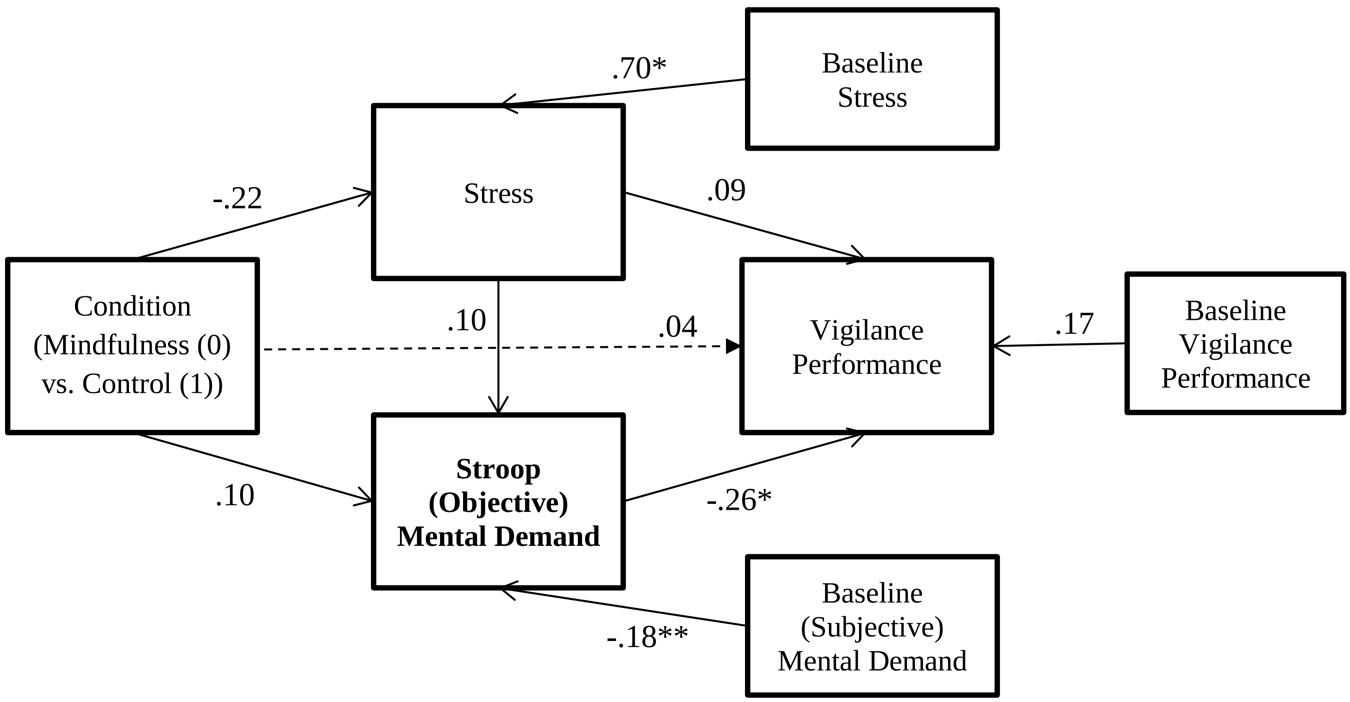


Figure 12. Objective Mental Demand (Stroop) as Mediator. *p < .05; **p < .10. Standardized regression coefficients are shown. Baseline measures were entered as covariates.

Table 5

Objective Mental Demand (Stroop) as Mediator – Unstandardized Bootstrapped Estimates and Associated 95% Confidence Intervals

Path Estimated	Indirect effect	SE	CI (LL)	CI (UP)
Cond.→ Stress → Vig. Perf. (a_1* b_1)	-28.03	39.02	-121.81	32.87
Cond.→ Stroop → Vig. Perf. (a_2* b_2)	-36.03	86.80	-249.15	104.11
Cond.→ Stress → Stroop →Vig Perf. (a_1*a_3*b_2)	8.21	13.66	-5.49	46.49

Note. SE = Standard Error; CI = confidence interval; LL = lower limit; UL = upper limit.

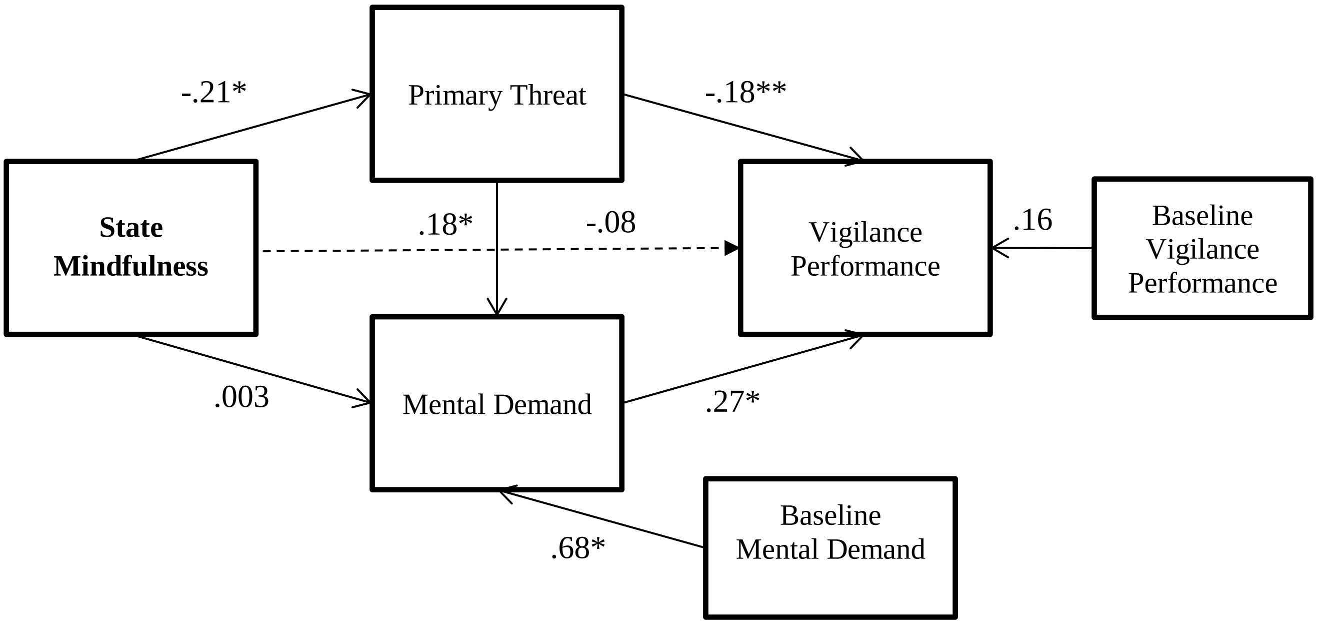


Figure 13. Primary Threat and Mental Demand Sequential Mediation Model – State Mindfulness Predictor. *p < .05; **p < .10. Standardized regression coefficients are shown. Baseline measures were entered as covariates.

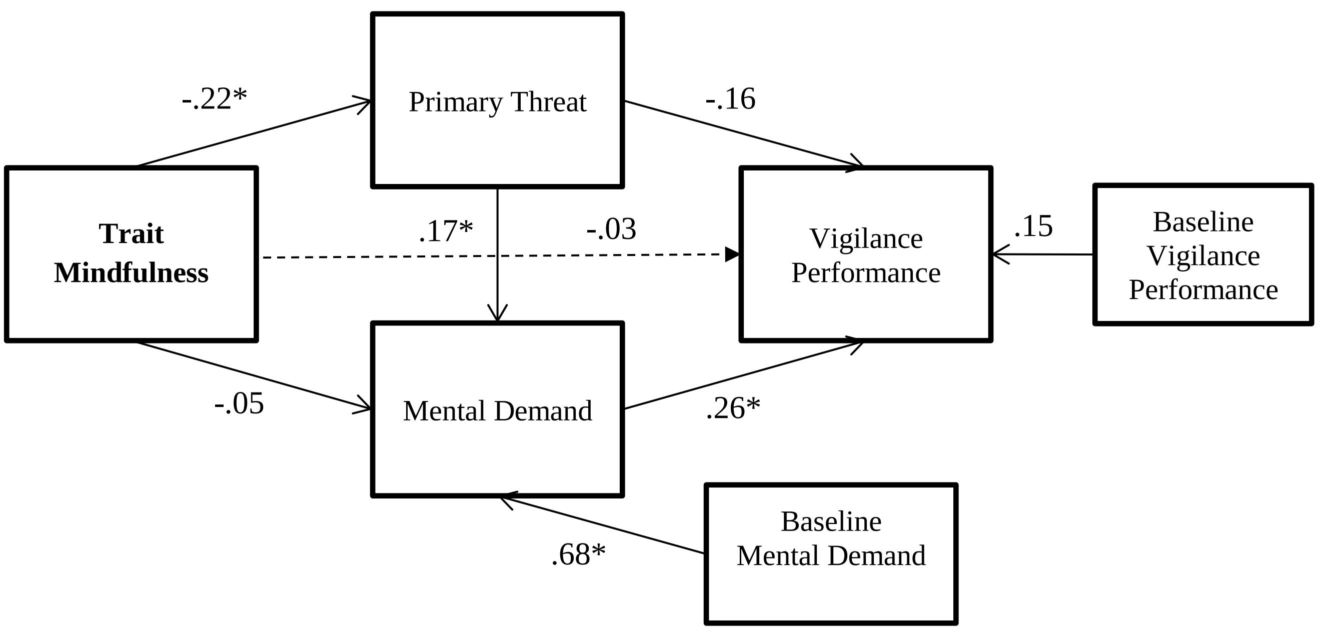


Figure 14. Primary Threat and Mental Demand Sequential Mediation Model – Trait Mindfulness Predictor. *p < .05; **p < .10. Standardized regression coefficients are shown. Baseline measures were entered as covariates.

Table 6

Primary Threat and Mental Demand Sequential Mediation Model – Unstandardized Bootstrapped Estimates and Associated 95% Confidence Intervals

Path Estimated	Indirect effect	SE	CI (LL)	CI (UP)
State Mindfulness as Predictor				
State Mindfulness → Primary Threat → Vig. Perf. (a_1* b_1)	88.90	59.39	-14.63	214.01
State Mindfulness → Mental Demand → Vig. Perf. (a_2* b_2)	-2.08	44.99	-104.76	81.01
State Mindfulness → Primary Threat → Mental Demand → Vig Perf. (a_1*a_3*b_2)	-23.48	16.40	-63.47	-.97
Trait Mindfulness as Predictor				
Trait Mindfulness → Primary Threat → Vig. Perf. (a_1* b_1)	102.68	76.85	-27.20	272.95
Trait Mindfulness → Mental Demand → Vig. Perf. (a_2* b_2)	-35.15	52.99	-157.13	58.05
Trait Mindfulness → Primary Threat → Mental Demand → Vig Perf. (a_1*a_3*b_2)	-26.91	19.57	-75.12	.17

Note. SE = Standard Error; CI = confidence interval; LL = lower limit; UL = upper limit.

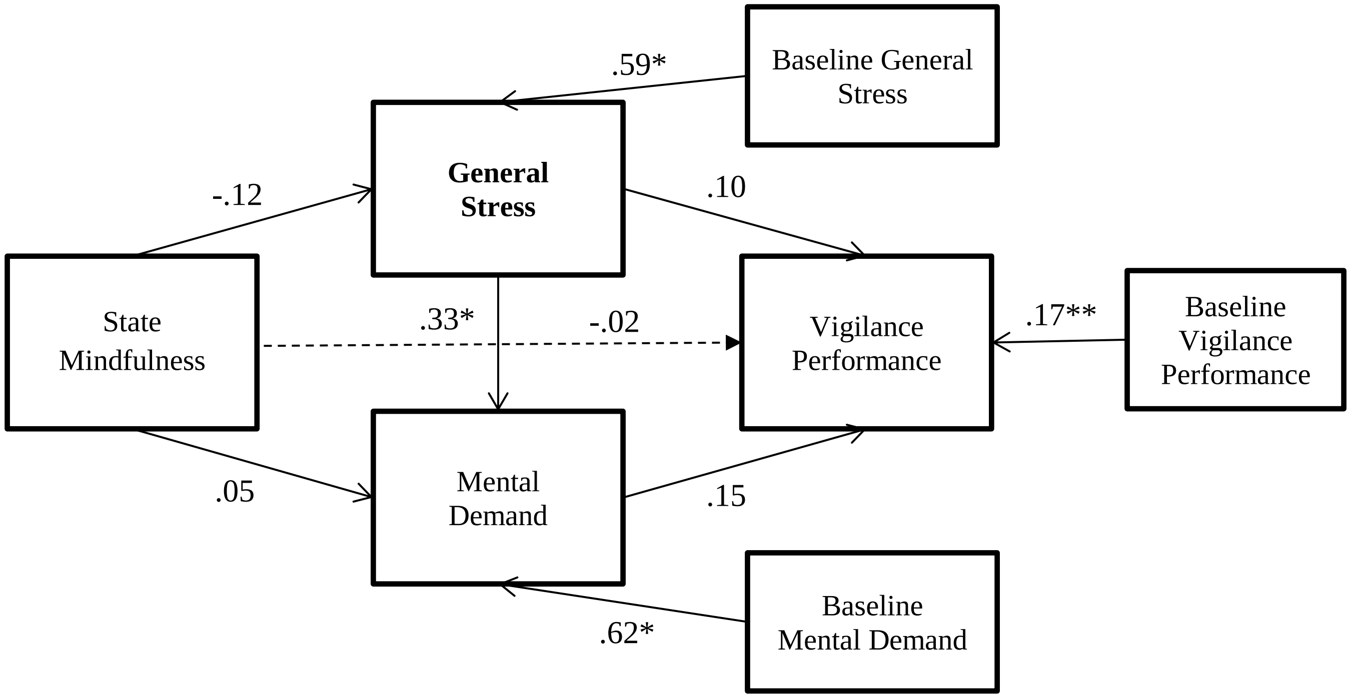


Figure 15. General Stress and Mental Demand Sequential Mediation Model – State Mindfulness Predictor. **p < .05; *p < .10; Standardized regression coefficients are shown. Baseline measures were entered as covariates.

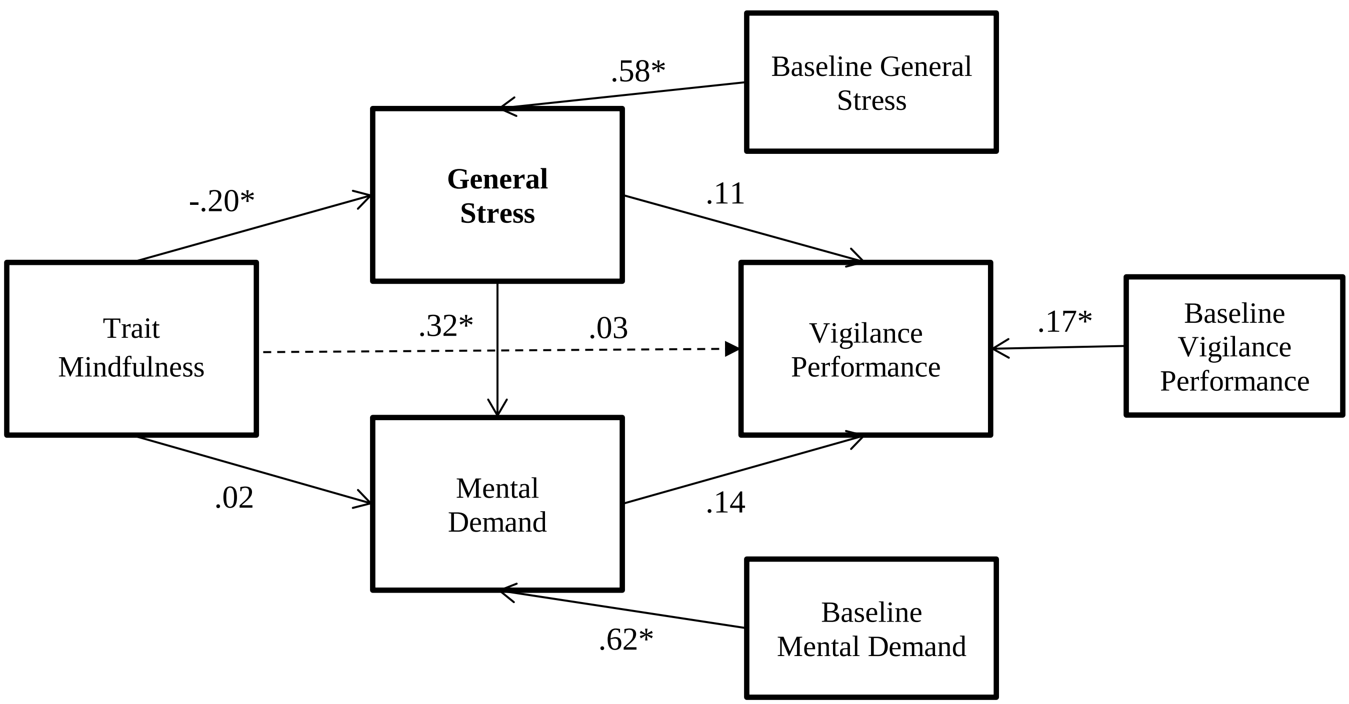


Figure 16. General Stress and Mental Demand Sequential Mediation Model – Trait Mindfulness Predictor. *p < .05; **p < .10. Standardized regression coefficients are shown. Baseline measures were entered as covariates.

Table 7

General Stress and Mental Demand Sequential Mediation Model – Unstandardized Bootstrapped Estimates and Associated 95% Confidence Intervals

Path Estimated	Indirect effect	SE	CI (LL)	CI (UP)
State Mindfulness as Predictor				
State Mindfulness → General Stress → Vig. Perf. ($a_1 * b_1$)	-25.89	43.70	-131.19	48.82
State Mindfulness → Mental Demand → Vig. Perf. ($a_2 * b_2$)	17.22	35.25	-46.20	100.61
State Mindfulness → General Stress → Mental Demand → Vig Perf. ($a_1 * a_3 * b_2$)	-13.72	18.85	-63.39	9.68
Trait Mindfulness as Predictor				
Trait Mindfulness → General Stress → Vig. Perf. ($a_1 * b_1$)	-65.90	79.02	-250.16	69.14
Trait Mindfulness → Mental Demand → Vig. Perf. ($a_2 * b_2$)	4.97	30.72	-60.93	70.85
Trait Mindfulness → General Stress → Mental Demand → Vig Perf. ($a_1 * a_3 * b_2$)	-26.95	26.18	-92.54	12.31

Note. SE = Standard Error; CI = confidence interval; LL = lower limit; UL = upper limit.

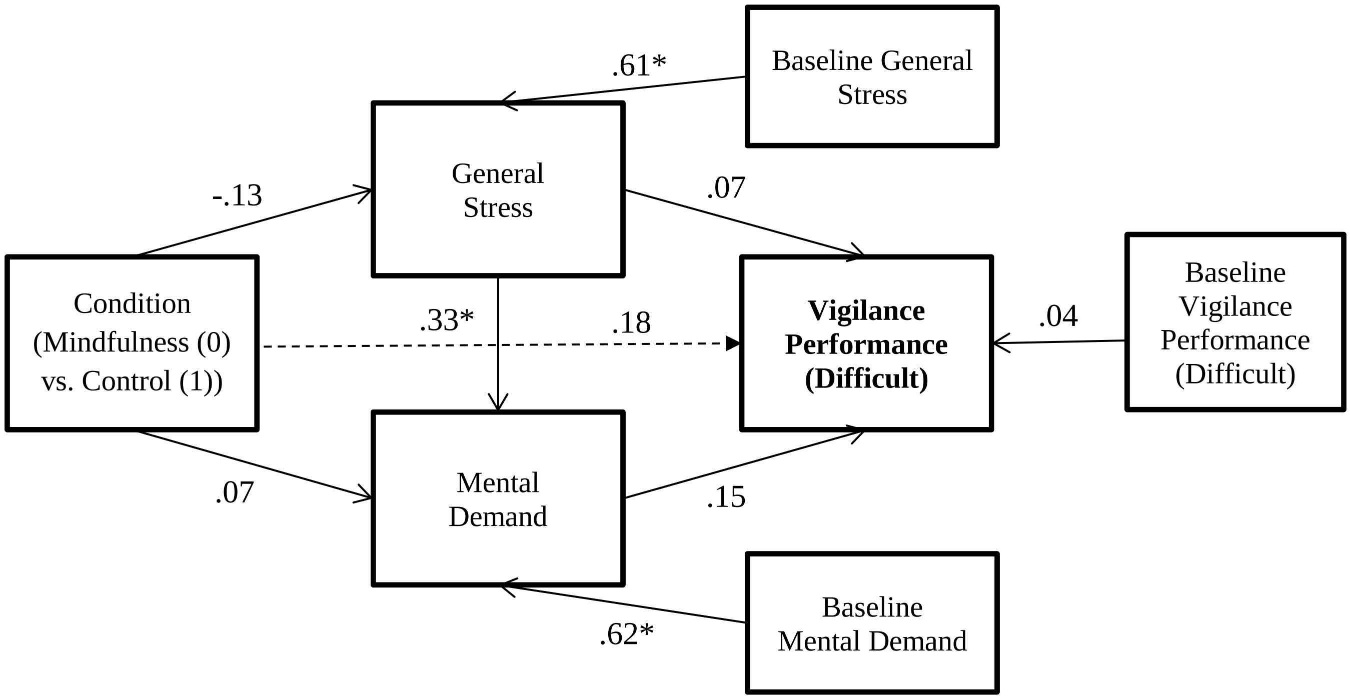


Figure 17. Difficult Trials Only – Condition as Predictor. *p < .05; **p < .10. Standardized regression coefficients are shown. Baseline measures were entered as covariates.

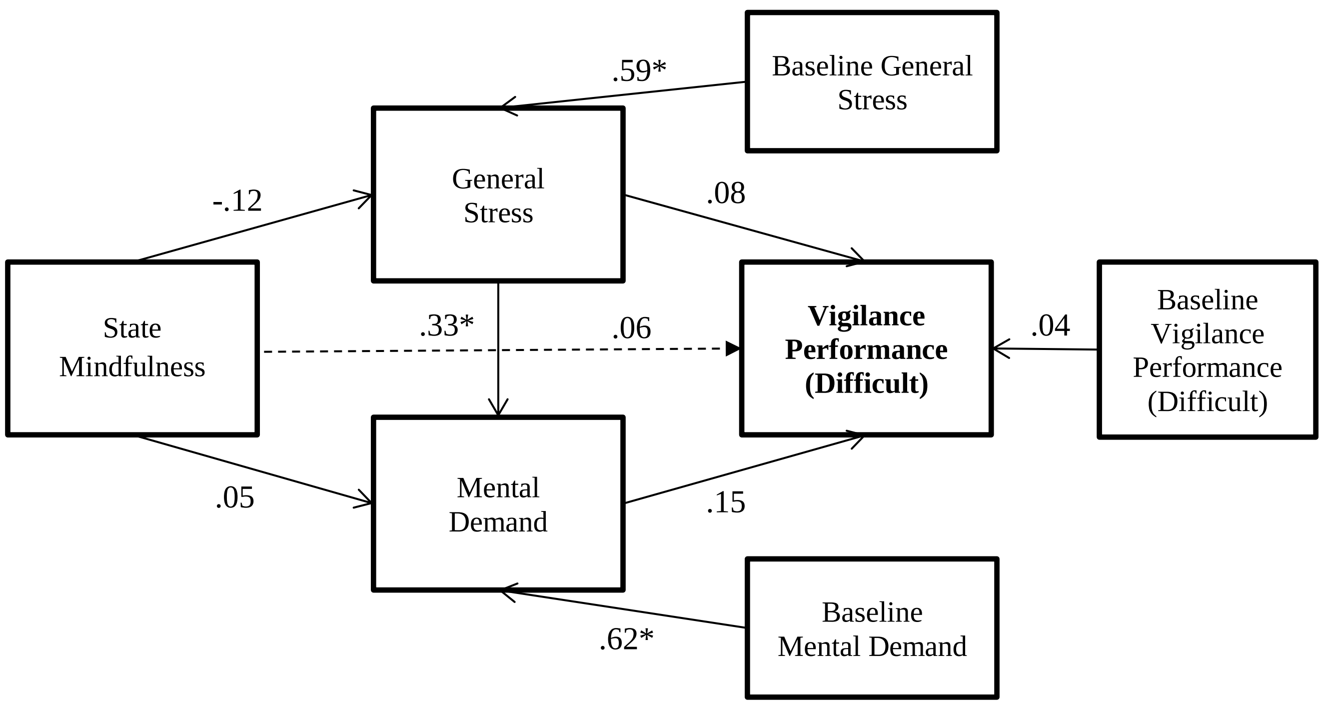


Figure 18. Difficult Trials Only – State Mindfulness as Predictor. *p < .05; **p < .10. Standardized regression coefficients are shown. Baseline measures were entered as covariates.

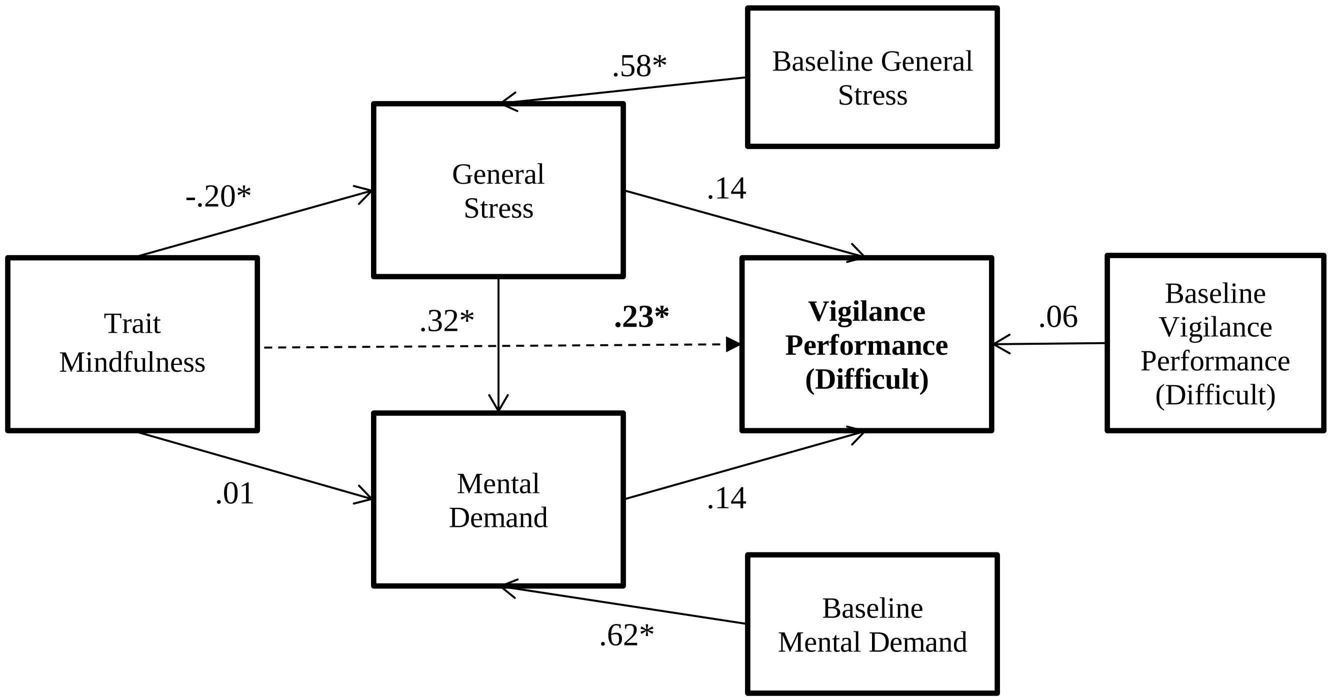


Figure 19. Difficult Trials Only – Trait Mindfulness as Predictor. *p < .05; **p < .10. Standardized regression coefficients are shown. Baseline measures were entered as covariates. Key model finding (Trait Mindfulness → Vigilance Performance (Difficult)) in bold.

Table 8

Various Models – Difficult Trials Only – Unstandardized Bootstrapped Estimates and Associated 95% Confidence Intervals

Path Estimated	Indirect effect	SE	CI (LL)	CI (UP)
Condition as Predictor				
Cond. → General Stress → Vig. Perf. (Diff. Only) (a_1* b_1)	-11.68	31.83	-83.94	51.50
Cond. → Mental Demand → Vig Perf. (Diff. Only) (a_2* b_2)	13.44	31.80	-46.20	88.68
Cond. → General Stress →Ment. Demand →Vig Perf. (Diff. Only) (a_1*a_3*b_2)	-8.09	13.93	-40.78	15.45
State Mindfulness as Predictor				
State Mind.→ General Stress → Vig. Perf. (Diff. Only) (a_1* b_1)	-17.69	37.42	-104.16	51.99
State Mind.→ Mental Demand → Vig. Perf. (Diff. Only) (a_2* b_2)	14.63	33.59	-31.28	104.71
State Mind.→ General Stress → Mental Demand → Vig Perf. (Diff. Only) (a_1*a_3*b_2)	-11.66	16.77	-54.88	10.53
Trait Mindfulness as Predictor				
Trait Mind.→ General Stress → Vig. Perf. (Diff. Only) (a_1* b_1)	-67.16	70.61	-228.27	49.93
Trait Mind.→ Mental Demand → Vig. Perf. (Diff. Only) (a_2* b_2)	4.07	27.56	-52.99	65.63
Trait Mind.→ General Stress → Mental Demand → Vig Perf. (Diff. Only) (a_1*a_3*b_2)	-22.10	24.73	-84.54	66.96

Note. Cond. = Condition; Vig. Perf. (Diff. Only) = Vigilance Performance (Difficult Trials Only); SE = Standard Error; CI = confidence interval; LL = lower limit; UL = upper limit.

Table 9

Correlations among Exploratory and Core Study Variables

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Exploratory Variables:															
1	State Mindfulness	.74													
2	Trait Mindfulness	.23*	.82												
3	Primary Threat	-.21*	-.22*	.80											
4	General Stress (T1)	-.24*	-.17**	.47*	.84										
5	General Stress (T2)	-.26*	-.30*	.34*	.62*	.67									
6	Objective Mental Demand (Stroop)	.03	.14	.00	-.11	.03	-								
7	Vigilance Performance (Diff- T1)	.04	-.08	-.02	.06	.05	-.09	-							
8	Vigilance Performance (Diff- T2)	.04	.17**	-.09	-.01	.14	-.16**	.06	-						
Core Variables:															
9	Condition	.04	.21*	.07	-.13	-.14	.03	.06	.08	-					
10	Stress (Task-Based; T1)	-.01	-.11	.27*	.49*	.22*	-.09	.03	.01	-.11	.77				
11	Stress (Task-Based; T2)	-.04	-.17**	.25**	.41*	.37*	.05	.02	.03	-.19**	.71*	.83			
12	Mental Demand (T1)	.07	-.01	.27*	.48*	.32*	-.15	.06	.11	-.01	.31*	.24*	.77		
13	Mental Demand (T2)	.00	-.09	.36*	.47*	.52*	-.01	.11	.19	-.02	.20*	.34*	.73*	.75	
14	Vigilance Performance (T1)	-.01	-.15	-.02	.19**	.11	-.15	.73*	.15	.02	-.03	-.05	.13	.15	-
15	Vigilance Performance (T2)	-.05	-.04	-.07	.00	.20**	-.28*	.13	.78*	-.01	.03	.07	.12	.23*	.20*

-*Note*. Diff. = Difficult Trials. * p < .05.; ** p < .10. Scale reliabilities are shown on the diagonal

Table 10

Correlations among Mindfulness Scales and Traditional Vigilance Predictors

Variable	*M*	*SD*	1	2	3	4	5	6
State Mindfulness	3.49	.97						
Trait Mindfulness	3.43	.50	.23*					
Sleep Quality	2.42	.64	-.27*	-.10				
Caffeine	66.40	101.94	-.04	-.18**	.03			
Vigilance Experience	2.31	1.29	-.05	.04	.09	.10		
Self-Efficacy	3.43	.97	.29*	.30*	-.04	.17*	.03	
Break	3.48	.89	.37*	.26*	.07	-.02	-.02	.31*

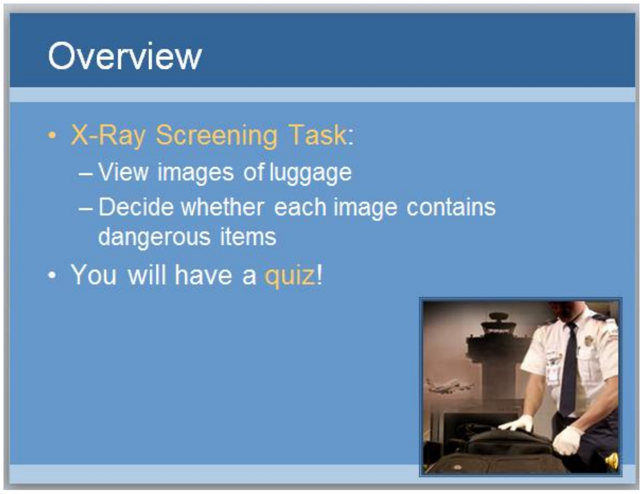
Note. Self-Efficacy refers to confidence in vigilance task performance; Break refers to the degree to which one enjoyed the break (experimental manipulation) and followed instructions; Vigilance Experience refers to experience in vigilance tasks. * $p < .05$.; ** $p < .10$.

Appendix B

X-Ray Screening Training Materials

Merritt, 2011

Slide 1



Audio instructions

- In a few minutes, you're going to work on an X-ray Screening Task. That means you'll be looking at X-ray images of luggage, and you'll need to decide whether or not the suitcase contains dangerous items.
- X-ray screening such as the simulation you're working on here is important for transportation security reasons, so please do your best on this task.
- Before you begin, you're going to go through a short training program to teach you how to complete the X-ray Screening Task. After the training program is over, you'll have a quiz on the material presented here, so please be sure you're paying attention.

Slide 2

Audio instructions

- On this task, you'll be looking at pictures that show X-ray images of suitcases and bags. You can see X-ray pictures of the items within the bags. Some suitcases will contain only a few items; others will contain many items.
- Your most important concern is to search for two types of dangerous items: guns and knives. In real life, there are many types of items that are prohibited for air travel, such as scissors, files, flammable liquids, and explosives. However, in this task, you only need to worry about detecting guns and knives.
- So, for each X-ray suitcase or bag you view, you'll need to decide whether to SEARCH or CLEAR the bag. If you think the bag contains a gun or a knife, click on SEARCH. If you think the bag does not contain a gun or a knife (in other words, you think the bag is safe), click on CLEAR.

Slide 3

Audio Instructions

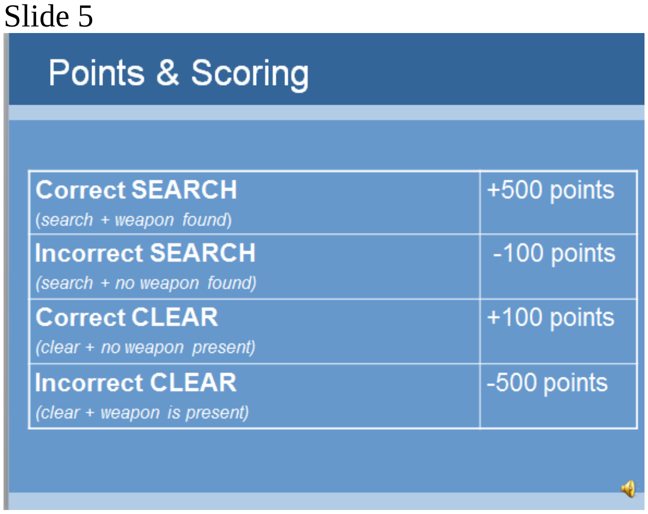
- Here's a picture that clearly has a knife in it. *Put a circle around the knife.* In this case it's obvious because the blade is extended and the entire knife is visible. However, sometimes it won't be this easy to see the dangerous items. Sometimes they will be obscured behind other objects in the suitcase, and sometimes they'll be arranged at an angle where it isn't obvious what they are.

Slide 4

Audio Instructions

- For example, look at this item. *Circle the gun.* It's hard to tell what it is. Maybe it's a cell phone. Actually, this is a gun viewed from the top looking down onto the barrel. *Show gun from multiple angles.* Because you can't see the handle, it's harder to tell that this is a dangerous weapon, so look carefully!

Slide 5



Audio Instructions

- As you're working, you'll receive points for each correct decision you make and lose points for each incorrect decision you make. Obviously, your goal is to maximize the number of points you have at the end of the simulation. Carefully study the points chart below, because you're going to have a quiz on it in a minute.
- In real life, it's much more important to catch weapons than anything else, but in this simulation, it is different. Here, you get points for *correct* decisions, regardless of what type of decision it is. So, correctly searching a bag with a weapon in it is worth the same number of points as correctly clearing a bag with no weapon in it.

Similarly, an incorrect search decision and an incorrect clear decision both result in 0 points. So, you should focus on just making *correct* decisions.

Appendix C

Experimental Manipulation Script

Adapted from Segal, Williams, and Teasdale, 2002 and Arch & Craske, 2005

On-screen Written Instructions for Both Conditions

X-ray Screening Break

“Now we’re going to do an exercise for 15 minutes. First, settle into a comfortable sitting position. Though you may find the next activity to be unique, you are encouraged to embrace it. Please get comfortable, relax, and follow the instructions to the best of your ability for this short 15-minute exercise. Afterwards, you will engage in a second baggage screening task.”

Please press “Next” to listen to begin the exercise.

Mindfulness Induction Audio-Recording Script

1. Now we’re going to do an exercise for 15 minutes.

2. First, settle into a comfortable sitting position, sitting with your back straight against the back of the chair <pause>, your legs uncrossed <pause>, your feet flat on the floor <pause> and your hands in your lap. <pause> Now gently close your eyes. Ask yourself, “What is my experience right now? What am I thinking about? What am I feeling emotionally? What sensations are present in my body?” Just observe your experience, whatever it is. <pause pause>

3. Bringing your awareness to your body, focus your attention on the sensations of touch or pressure where your body makes contact with the chair. Spend a moment or two exploring these sensations. <pause pause>

4. Now bring your attention to the changing physical sensations in your lower abdomen the breath moves in and out of your body. To help you pay attention to your breathing, place your hand on your lower abdomen, and become aware of the changing sensations where your hand makes contact with your abdomen. <pause pause> When you’ve “tuned in” to the physical sensations in this area, you can remove your hand if you like, and continue to focus on the sensations in your abdomen. <pause>

5. Focus your awareness on the sensations of slight stretching as the abdomen rises with each inbreath, and of gentle deflation as it falls with each outbreath. Pay attention as best you can to the changing physical sensations in the lower abdomen all the way through as the breath enters your body on the inbreath, and all the way through as the breath leaves your body on the outbreath <pause pause> perhaps also noticing the slight

pause at the end of the inbreath, and the slight pause between the end of one outbreath and the beginning of the next inbreath. <pause>

6. Focusing on the actual sensations of breath entering <pause> and breath leaving the body <pause> There is no need to think about the breath – just experience the sensations of it. And there is no need to try to control the breathing in any way - simply let the breath be natural. As best you can, also bring this sense of allowing to the rest of your experience. There is nothing to be fixed, no particular state to be achieved. As best you can, simply allow your experience to be your experience, without needing to change it in any way. <pause pause>

7. Sooner or later your mind will wander away from the focus on the breath in the lower abdomen to thoughts, feelings, daydreams, drifting along - whatever. This is perfectly OK – it's simply what minds do. When you notice that your awareness is no longer on the breath, acknowledge gently and briefly where the mind has been. Then, gently bring your awareness back to the changing physical sensations in the lower abdomen, renewing your intention to pay attention to the breath coming in and breath going out. <pause>

8. Whenever you notice that the mind has wandered (and this may happen over and over again), congratulate yourself each time on reconnecting with your experience in the moment, gently escorting the attention back to the breath, and simply continue in noticing the physical sensations that come with each inbreath and outbreath. <pause>

9. Now simply continue with this, perhaps reminding yourself from time to time that the intention is simply to be aware of your experience in each moment, as best you can, using the breath as an anchor to gently reconnect with the here and now each time you notice that your mind has wandered and is no longer down in the abdomen, following the breath. <pause>. I'll let you know when it's time to move on to something else. <pause for 3 minutes>

10. Now allow your attention to expand to your whole body, <pause> to your posture, <pause> your facial expression, <pause> and other parts of your body <pause pause>. Continue with this <pause <pause pause>.

11. Now when you are ready, slowly and gently open your eyes. <pause pause>

Unfocused Attention Induction Audio-Recording Script

1. Now we're going to do an exercise for fifteen minutes.

2. First, settle into a comfortable sitting position. Now simply think about whatever comes to mind. Let you mind wander freely without trying to focus on anything in particular. Just let you mind roam as it normally would <pause pause>

3. Now simply continue with letting your mind wander and think about whatever you want. I’ll let you know when it’s time to move on to something else <pause 5 minutes>

4. Continue letting your mind wander, letting your thoughts go wherever they take you. <pause 3 minutes> (repeat variants of this instruction, then wait another 4 min)

5. Remember to just continue letting your mind wander, and follow wherever it takes you.

6. Just think about whatever comes to your mind. I’ll let you know when it’s time to move on to something else

7. Now we will move on to the next part of the study.

Appendix D

Study Items

State Mindfulness (Mindful Attention Awareness Scale; Brown & Ryan, 2003)

To what degree were you having the following experiences during the audio-recorded activity you engaged in during your break in between the X-ray screening tasks (where, for 15 minutes, you were instructed to settle into a comfortable sitting position and follow the guided instructions)? Please answer honestly about your experience.

1	2	3	4	5
Not at all	Very little	Somewhat	Quite a bit	Very much

1. During the break…I found it difficult to stay focused on what was happening in the present.
2. I was eager to rush through the activity without being really attentive to it
3. I did the activity automatically, without being aware of what I was doing.
4. I found myself preoccupied with the future or the past.
5. I found myself doing the activity without paying attention.

Additional exploratory items:

6. I devoted my full attention to following the instructions.
7. I made an effort to do what the instructions told me to do.
8. I stayed "in the moment," limiting my thoughts about what my previous or next task was.
9. When I noticed an absence of mind, I gently returned to the experience of the here and now (from Freiburg Mindfulness Inventory)
10. I accepted my thoughts without judging them (adapted from Freiburg Mindfulness Inventory)
11. I feel connected to my experience in the here-and-now. (from Freiburg Mindfulness Inventory

Stress (Short Stress State Questionnaire (SSSQ); Helton, 2004)

Please indicate how true each statement was of your thoughts While Performing The X-Ray Screening Task.

1	2	3	4	5
Not at All	A little bit	Somewhat	Very Much	Extremely

1. I was committed to attaining my performance goals
2. I wanted to succeed on the task
3. I was motivated to do the task

4. I tried to figure myself out.
5. I reflected about myself.
6. I daydreamed about myself.
7. I felt confident about my abilities.
8. I felt self-conscious.
9. I was worried about what other people think of me.
10. I felt concerned about the impression I was making.
11. I performed proficiently on this task.
12. Generally, I felt in control of things.
13. I thought about how others have done on this task.
14. I thought about how I would feel if I were told how I performed.

General Stress (Gaab et al., 2003)

"At this moment,"

1	2	3	4	5
Not at All	A little bit	Somewhat	Very Much	Extremely

1. I feel stressed
2. I feel calm and relaxed

Mental Workload (NASA Task Load Index; Hart & Staveland, 1988)

Use the follow scale to answer the following items about the X-Ray screening task.

0	1	2	3	4	5	6	7	8	9
Lowest									Highest

1) Mental Demand:

How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, forgiving or exacting?

2) Physical Demand:

How much physical activity was required (e.g., pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?

3) Temporal Demand:

How much time pressure did you feel due to the rate of pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?

4) Performance:

How successful do you think you were in accomplishing the goals of the tasks? How satisfied were you with your performance in accomplishing these goals?

5) Effort:

How hard did you have to work (mentally and physically) to accomplish your level of performance?

6) Frustration Level:

How insecure, discouraged, irritated, stressed, and annoyed versus secure, gratified, content, relaxed, and complacent did you feel during the task?

Compliance with Instructions

For the next set of items, recall the audio-recorded activity you engaged in during your break in between the X-ray screening tasks, in which, for 15 minutes, you were instructed to settle into a comfortable sitting position and follow the guided (focused breathing or unfocused attention) instructions.

During this break, how would you rate the extent to which you tried to follow the instructions to the best of your ability?

1	2	3	4	5
Not at all	Slightly	Somewhat	Very	Very Much

To what extent did you enjoy the break?

1	2	3	4	5
Not at all	Slightly	Somewhat	Very	Very Much

To what extent do you agree the break was a good use of your time?

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Self-Efficacy (X-ray screening task)

How confident did you feel in carrying out this task?

1	2	3	4	5
Not at all	Slightly	Somewhat	Very	Very Much

Trait Mindfulness (Freiburg Mindfulness Inventory; Walach et al., 2006)

The purpose of this inventory is to characterize your experience of mindfulness. Provide an answer the for every statement as best you can. Please answer as honestly and spontaneously as possible. There are neither 'right' nor 'wrong' answers, nor 'good' or 'bad' responses. What is important to us is your own personal experience. Indicate to what extent you experience these items in general, that is, on average. Use the following response scale.

1	2	3	4	5
Never	Rarely	Occasionally	Fairly Often	Almost always

1. I am open to the experience of the present moment.
2. I sense my body, whether eating, cooking, cleaning or talking.
3. When I notice an absence of mind, I gently return to the experience of the here and now.
4. I am able to appreciate myself.
5. I pay attention to what's behind my actions.
6. I see my mistakes and difficulties without judging them.
7. I feel connected to my experience in the here-and-now.
8. I accept unpleasant experiences.
9. I am friendly to myself when things go wrong.
10. I watch my feelings without getting lost in them.
11. In difficult situations, I can pause without immediately reacting.
12. I experience moments of inner peace and ease, even when things get hectic and stressful.
13. I am impatient with myself and with others.
14. I am able to smile when I notice how I sometimes make life difficult.

Challenge-Threat Scale (Drach-Zahavy & Erez, 2002)

Please indicate how true each statement was about your thoughts while you were performing the X-Ray Screening Task.

1	2	3	4	5
Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

Primary challenge appraisals:

- ‘‘The task seemed like a challenge to me.’’
- ‘‘The task provided opportunities to overcome obstacles.’’
- “This task provided opportunities to exercise reasoning skills.’’
- ‘‘The task provided opportunities to strengthen my self-esteem.’’

Primary threat appraisals:

- ‘‘The task seemed like a threat to me.’’
- ‘‘I was worried that the task might reveal my weaknesses.’’
- ‘‘The task seemed long and tiresome.’’
- ‘‘I was worried that the task might threaten my self-esteem.’’

Secondary challenge appraisals:

- Overall, I thought that I would succeed in carrying out the task.
- I thought that I had the abilities necessary for successful performance.

Secondary threat appraisals:

- Overall, it seemed that I could not succeed in a task like this.
- I was worried that I lacked the abilities to perform the task successfully.

Sleep Quality (The Epworth Sleepiness Scale; Johns, 1991)

What is the likelihood that you will doze off or fall asleep in the following situations at this moment, in contrast to just feeling tired:

1	2	3	4	5
Very little or no chance of dozing	Slight chance of dozing	Moderate chance of dozing	Great chance of dozing	Very great chance of dozing.

1. Sitting and reading
2. Watching TV
3. Sitting inactive in a public place (e.g., a theater or a meeting)
4. As a passenger in a car for an hour without a break
5. Lying down to rest in the afternoon when circumstances permit
6. Sitting and talking to someone
7. Sitting quietly after a lunch without alcohol
8. In a car, while stopped for a few minutes in traffic

Caffeine Consumption (Brick, Seely, & Palermo, 2010)

How many servings (e.g., 1 cup, 1 can) of the following caffeinated beverages have you had so far today?

1. Coffee __
2. Soda __
3. Tea __
4. Energy drinks __