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Effects of heat stress on risk perceptions and risk taking

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ABSTRACT

Exposure to extreme heat at work is a serious occupational hazard, as exposure can result in heat-related illnesses, and it has been linked to increased risk of accidents and injuries. The current study aimed to examine whether heat exposure is related to changes in individuals' psychological process of risk evaluation, and whether acclimatization can mitigate the effect of heat exposure. A study with quasi-experiment research design was used to compare participants' risk perceptions and risk-taking behaviors at baseline, initial exposure to heat, and exposure after acclimatization across male participants who were exposed to heat (N = 6), and males (N = 5) and females (N = 6) who were in the control group who were exposed to ambient temperature. Results show that participants perceived the same risky behaviors to be less risky ($p = 0.003$) and demonstrated increased risk-taking behaviors ($p = 0.001$) after initial heat exposure. While their risk perceptions returned to baseline level after acclimatization, their risk-taking behaviors remained heightened ($p = 0.031$). Participants who were not exposed to heat showed no significant fluctuation in their risk perceptions and risk-taking. Our findings support that risk-related processes may explain the effects of heat exposure on increased accidents and injuries beyond its direct impact on heat-related illnesses.

1. Introduction

Exposure to extreme heat that is either due to higher ambient temperature in the work environment (e.g., outdoor labors) or from performing the job tasks (e.g., wielders) is considered a physical occupational hazard (National Institute for Occupational Safety and Health [NIOSH], 2016). This exposure can directly result in workers suffering from heat stress, or heat-related illnesses that range from mild irritations such as heat rash or cramps to serious conditions such as heat exhaustion. Without emergency medical attention, heat stroke, the most severe form of heat stress, can lead to death or permanent disability. For example, between years of 1992 and 2006, a total of 423 occupational fatalities from exposure to environmental heat were reported in the United States (Center for Disease Control and Prevention, 2008).

Moreover, heat exposure has also been considered as a threat to workers' safety. Research has demonstrated a linkage between heat exposure to increased rate of unsafe behaviors (Ramsey et al., 1983) and acute injuries (Fogleman et al., 2005; Garzon-Villalba et al., 2017). The slipperiness of sweaty palms, the fogging of safety equipment due to heat, and impaired physical performance are often blamed for such increases (NIOSH, 2016). In addition, research has shown that heat may increase individuals' irritation and hostility levels (Anderson, 2001), as well as their ability to stay alert or concentrated (Hancock and Vasmatzidis, 2003). These psychological variations may cause workers to overlook safety procedures or to divert attention from hazardous tasks. Unfortunately, other than cognitive, psychomotor, and perceptual performance such as reaction times or vigilance (see Hancock and Vasmatzidis, 2003 for a review), the psychological mechanisms through which heat exposure may influence workers' safety practices have not received much research attention. In addition, while it has been well-established that heat acclimatization improves the physiological responses to heat exposure, equivocal evidence exists for whether or how acclimatization may impact participants' psychological functioning (Gaoua, 2010).

One of such overlooked psychological processes is individuals' risk-related attitudes and behaviors. Considering the effects of heat exposure on individuals' risk perceptions and risk-taking is important for three reasons. First, when employees choose to ignore safety practices at work, such behavior can be conceptualized as a domain specific (i.e., health and safety) risk-taking

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behavior. Based on the principle of specificity (Ajzen and Fishbein, 1977), theory of planned behavior purports that a domain-specific attitude (i.e., attitudes about health and safety risks) is likely to be the best predictor for employees' health and safety risk-taking behavior. As such, changes in health and safety risk perceptions may help explain how heat exposure relates to employees' risky behaviors, and the resulting accidents, injuries, and even fatalities, at work. Next, understanding the risk-related mechanisms underlying the heat exposure and employees' behaviors at work may help identify additional intervention opportunities to prevent heat-related accidents at work. In this case, instead of managing the symptoms of heat exposure, interventions may target the psychological processes that are affected by the heat in order to reduce the risk for accidents and injuries. Finally, it is important to begin to explore if acclimatization has any effect on the risk-related psychological processes beyond the physiological adaptation. This research has been largely missing in the existent literature. Knowledge about this link may provide additional support for the importance of acclimatization practice.

The purpose of the current study is to examine if heat exposure alters individuals' risk-related psychological processes, including risk perceptions and risk-taking behaviors, and whether effects of heat exposure changes due to acclimatization. We will integrate the maximal adaptability model (Hancock and Warm, 1989), which explains the effects of heat exposure on individuals' cognitive performance, with the risk-return framework (Sarin and Weber, 1993) to hypothesize effects of heat exposure on individuals' risk perceptions and risk-taking attitudes after the initial and acclimatized exposures. Results from a quasi-experiment will be used to evaluate the proposed hypotheses.

1.1. Heat exposure and cognitive performance: the maximal adaptability model

Heat exposure can lead to various physiological responses, such as increased metabolic rate and body temperature, and physical reactions, such as reduced physical capabilities to perform strenuous tasks (Ahasan et al., 2002). Heat exposure may also impact individuals' cognitive performance. The maximal adaptability model (Hancock and Warm, 1989) describes how heat exposure taxes individuals' finite attentional coping resources that can be deployed to respond to environmental demands. When individuals are in a benign, nonstressful environment, their physiological and psychological functioning is within the normative zone, which requires minimum coping effort. As the environment becomes more demanding (e.g., prolonged exposure to heat, exposure to higher heat intensity), more attentional coping resources are necessary in order to maintain their cognitive functioning. Individuals may cope with initial heat exposure successfully by mobilizing resources, thereby maintaining or even enhancing their cognitive performance. However, as individuals continue to deploy energy to cope with the heat exposure, their attentional resources are eventually drained, thus pushing them outside of boundary of maximal psychological adaptability, and their cognitive performance is likely to deteriorate exponentially.

Indeed, empirical research has shown that heat exposure affects individuals' cognitive functioning differently depending on the type of cognitive tasks performed. Faervik and Reinertsen (2003) exposed their participants to three separate temperature variations (i.e., cold, warm, and hot) for 3 h, and observed their performance on a vigilance test and a reaction task to rapidly changing visual and acoustic stimuli. While participants' performance to the reaction task did not vary based on the heat exposure conditions, their accuracy decreased significantly when they were in the hot condition. Similarly, Vasmatzidis et al. (2002) observed that tasks that required visual perceptual input and manual response output were more sensitive to the effects of heat exposure, whereas tasks that require working memory processing capacity (e.g., memory search) were less affected.

The duration and intensity of the exposure and participant characteristics may also moderate the effects of heat on individuals' cognitive performance. Performance on psychomotor tasks may improve after the initial exposure (Gaoua, 2010). Meta-analytic results also supported the general trend that performance deteriorated more with longer exposure (up to 3 h; Hancock et al., 2007). In addition, exposure to different temperatures was associated with different performance detriments (Hancock et al., 2007). Finally, participants' demographic variables (e.g., sex) and acclimatization experiences may also impact how heat exposure affect their psychological functioning (Gaoua, 2010). These results suggest the importance of controlling for these extraneous factors when investigating psychological effects of heat exposure.

1.2. Risk return framework

The risk return framework suggests individuals' perceived risk attitude for an option is determined by the expected benefits and the riskiness of the option (Weber, 1998). Based on this framework, the context or domain in which the behavioral option resides can have meaningful effects on individuals' perceived risk attitudes for the action (Weber et al., 2002; Weber and Milliman, 1997). Interestingly, while the perceived riskiness of the options appears to change across domains, perceived riskiness of the behavior significantly predicted individuals' intention to engage in the target behavior, regardless of the domains (Weber et al., 2002). Thus, the current study will focus on the perceived riskiness of a specific domain—health and safety, as this domain corresponds to the workplace accident and injuries.

Three primary determinants of perceived riskiness of a given option are commonly discussed: probability of the consequence, severity of the consequence, and affective responses (e.g., Oglethorpe and Monroe, 1994; Leventhal et al., 2003). Perceived risk for a course of action increases if individuals believe that the probability of the action leading to a negative outcome is high and uncontrollable (Kaptein et al., 2007; Oglethorpe and Monroe, 1994). In addition, if they can readily recall the negative consequences of the behavior, and these consequences are immediate and nonreversible, this information increases the perceived outcome severity and thus the perceived riskiness of the behavior (Oglethorpe and Monroe, 1994). Finally, if the behavioral option or the potential consequences elicit strong, negative emotional reactions (Kaptein et al., 2007), these anticipatory affective responses increase the perceived riskiness of the behavior. Studies have supported that individuals consider a behavior riskier when they perceived the frequency of its negative consequences to be higher, more severe, and less controllable (e.g., Harris et al., 2008; White et al., 2004). Those who experience more negative affect such as anxiety, depression, and guilt (e.g., Ajcardi and Therme, 2008; Becker-Olsen and Briones, 2009; Gerend et al., 2004; Yao and Liao, 2011) tend to perceive a behavior to be risky.

We propose that when individuals are exposed to heat, their risk perceptions of behavioral options related to health and safety may decrease, thereby making them more likely to engage in risky behaviors. Heat exposure may alter the risk perceptions of the health and safety behaviors as it changes individuals' assessment of the probability and severity of the possible negative consequences associated with such behaviors. For example, although studies have shown that individuals' working memory function is relatively intact when exposed to heat (Vasmatzidis et al., 2002), studies have shown that individuals have