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S Y M P O S I U M

INCORPORATING PHYSIOLOGY INTO CREATIVITY RESEARCH AND PRACTICE: THE EFFECTS OF BODILY STRESS RESPONSES ON CREATIVITY IN ORGANIZATIONS

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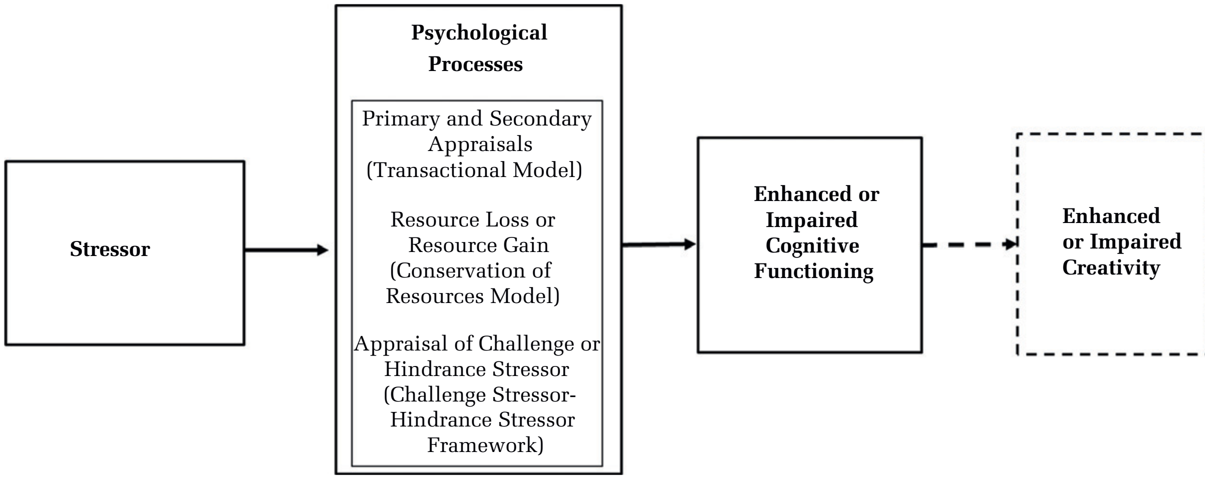
In the modern workplace, employees are required to be creative under varying stress levels. In understanding the relationship between stress and creativity, organizational scholars and practitioners have largely focused on how stress affects *cognition*, but have overlooked the role of *physiological responses* to stress. The present paper draws on psychophysiological theories of stress to highlight that the effect of stress on creative performance critically depends on whether stress-inducing situations engender "challenge" physiological states (i.e., fluid physiological stress responses) or "threat" physiological states (i.e., constrictive physiological stress responses). We integrate extant physiological and organizational theories of stress into research on creativity, identify physiological stress responses as overlooked mechanisms that help explain why stress differentially affects creativity, and provide practical information about how organizational scholars can incorporate physiological measures into research on creativity.

Creativity, a multidimensional construct commonly defined as the production of novel and useful ideas or solutions (Amabile, 1983),[1] is considered critical to individual and organizational success (Amabile, 1996; Hennessey & Amabile, 2010; Zhou & Hoever, 2014). Employees can be a key source of creative ideas, services, products, processes, and procedures (Woodman, Sawyer, & Griffin, 1993) that help organizations innovate (Mumford & Gustafson, 1988). Further, there is evidence that when employees enact their creativity, they can experience more positive affect at work (Amabile, Barsade, Mueller, & Staw, 2005), greater work satisfaction, and heightened intrinsic motivation (Amabile, 1996; Amabile et al., 2005).

Given the importance of creativity, organizational scholars and practitioners alike have devoted considerable attention to understanding the factors that enhance or inhibit individuals' creativity. These factors include individual-level characteristics (e.g., personality, expertise, cognitive style), job-level characteristics (e.g., stress, time pressure, job autonomy, rewards), and organizational-level characteristics (e.g., climate, human resources practices; for reviews, see Shalley & Gilson, 2004; Shalley, Zhou, & Oldham, 2004; Zhou & Hoever, 2014). As organizational life is replete with stress-inducing situations (Amabile, Hadley, & Kramer, 2002)—with over 80%

[1] Here we adopt a commonly used definition of creativity that focuses on creativity as a process. It is worth noting that other scholars have conceptualized it as an interaction among ability, process, and environment (e.g., Kaufman & Beghetto, 2009; Plucker, Beghetto, & Dow, 2004).

FIGURE 1
Traditional Organizational Models of Stress and Implications for Creativity



of employees experiencing stress on the job and citing stress as a key source of psychological and physical ailments (American Institute of Stress, 2017)—stress as a job-level characteristic has received increasing attention in organizational research.

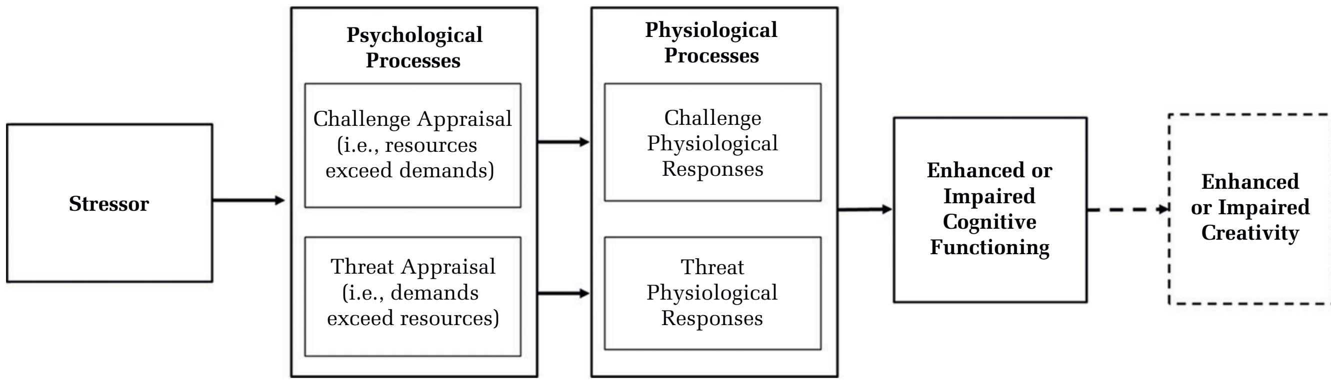
Stress is also a multidimensional construct that has been defined as an environmental characteristic that negatively affects people (e.g., Beehr, 1976), a disruption of homeostasis (Margolis & Kroes, 1974), a nonspecific bodily response to any demand (Selye, 1971), and a situation in which demands exceed an individual's coping resources (e.g., McGrath, 1976). Stress arises in various circumstances, such as when one's goals are threatened and when one encounters obstacles in attaining desired outcomes (Blascovich & Tomaka, 1996; Dickerson & Kemeny, 2004; Dienstbier, 1989; Lazarus & Folkman, 1984). Unfortunately for those seeking a parsimonious explanation for the effect of stress on creativity, studies have found negative (e.g., Amabile, Goldfarb, & Brackfleld, 1990), positive (e.g., Ohly & Fritz, 2010), and curvilinear (e.g., Byron, Khazanchi, & Nazarian, 2010) effects.

In our view, research on the effect of stress on creativity has been hampered by a failure to consider how *physiological* responses to stress can affect creative performance. To date, the majority of research has examined how stress affects creative performance via its effects on *cognitive* reactions to stress (e.g., cognitive appraisals) without accounting for the divergent physiological responses that are engendered by these cognitive reactions (see Figures 1 and 2). Indeed, a keyword search using the words *creativity*, *innovation*, *divergent*, or *creative* and co-search terms *anxiety*, *challenge*, *competition*, *evaluation*, *frustration*, *hassles*, *obstacles*, *overload*, *pressure*, *stress*, or *threat* (based on the methodology used by Byron et al., 2010) in eight of the top organizational behavior journals[2] (Podsakoff, MacKenzie, Podsakoff, & Bachrach, 2008; Tahai & Meyer, 1999) yielded 26 papers focusing on cognitive responses to stress and eight papers focusing on emotional responses to stress. Importantly, none of the papers considered how stress affects creativity via bodily reactions to stress.

This omission is problematic because physiological indicators can often provide unique insights into critical outcomes in organizations (e.g., creativity) beyond those provided by cognitive, emotional, and behavioral indicators. For example, one of the few studies that used physiological measures to better understand creative performance found that only physiological measures of vulnerability to a stressful situation—but not self-reported measures of vulnerability—predicted creative performance (Akinola & Mendes, 2008). Other scholars have found that physiological measures often predict behavior more reliably than self-report measures do (Josephs, Sellers, Newman, & Mehta, 2006). While much can be gained from measuring individuals'

[2] *Academy of Management Journal, Administrative Science Quarterly, Journal of Applied Psychology, Journal of Management, Journal of Organizational Behavior, Organizational Behavior and Human Decision Processes, Organization Science*, and *Personnel Psychology*.

FIGURE 2
The Biopsychosocial Model of Challenge and Threat and Implications for Creativity



self-reported reactions to stressors, self-report measures—like all measures—are imperfect. In particular, self-report measures suffer from issues related to construct validity (i.e., they are systematically contaminated by extraneous and irrelevant factors such as language ability, question order, etc.) and are susceptible to socially desirable responding and impression management (cf. Ones, Viswesvaran, & Reiss, 1995). Moreover, physiological measures may capture information that exists outside of conscious awareness, which is challenging to capture using self-report (Akinola, 2010; cf. Schultheiss, Campbell, & McClelland, 1999; Schultheiss, Dargel, & Rohde, 2003). Thus, incorporating physiological measures into organizational research on creativity has the potential to deepen theoretical insights on the relationship between stress and creativity.

In this paper, we argue that the conventional account of the role of stress in creativity is incomplete because it skips an important step in the causal pathway: the divergent physiological responses people have to stressors appraised as a "challenge" versus a "threat."[3] We draw on social psychological and physiological theories of stress to highlight that incorporating a physiological perspective on stress into the study of organizational creativity can (1) provide a mechanism for how stress affects cognition in ways that have positive or negative effects on creativity and (2) offer new methods of measuring stress that can inform whether it will enhance or impair creativity.

The remainder of this paper unfolds as follows. First, we introduce a prevailing physiological theory of stress—the biopsychosocial (BPS) model of challenge and threat (Blascovich, 2008; Blascovich & Tomaka, 1996)—and use this theory as a foundation to inform organizational scholars and practitioners about the role of physiological stress responses in creative performance in organizations. Second, we compare this physiological theory of stress with traditional models of stress in the organizational literature (the conservation of resources model, the transactional model of stress, and the challenge stressor–hindrance stressor framework) and illustrate how integrating this physiological theory into existing models may help offer important insights into pathways through which stress can positively, negatively, or curvilinearly affect creative performance. Third, we provide a practical overview of the opportunities and challenges associated with incorporating physiological measures into organizational research. We conclude by discussing the implications of this physiology-centric perspective for future research, theory, and practice on organizational creativity.

THE BIOPSYCHOSOCIAL MODEL OF CHALLENGE AND THREAT

The BPS model describes the psychology and physiology engendered in motivated performance situations, such as when a manager has to give a speech in front of a large audience, or when a programmer has to develop innovative software

[3] Cognitive theories argue that physiological responses arise because of how individuals cognitively appraise situations (e.g., Lazarus, 1991; Tomaka, Blascovich, Kibler, & Ernst, 1997), whereas other theories argue that cognitive appraisals arise because of physiological responses (e.g., Cannon, 1927; Izard, 1993; LeDoux, 1996; Schachter & Singer, 1962). Because we ground our theorizing in the biopsychosocial model of stress, we take the perspective that appraisals precede physiological responses.

programs during a hackathon. Importantly, these performance situations are *active* and require instrumental cognitive responses (see Blascovich & Mendes, 2000). They are also *goal-relevant* in that the individual needs to believe that adequate performance is important for his or her continued growth, as motivated performance situations typically involve some sort of evaluation.[4]

According to Lazarus and Folkman (1984), in motivated performance situations, individuals psychologically evaluate whether they have the resources (e.g., knowledge, skills) to cope with the situational demands (e.g., danger, uncertainty, effort required). If individuals evaluate their resources as exceeding the demands of the situation, they are considered to appraise the situation as a "challenge"; if they evaluate the demands as exceeding their resources, they are considered to appraise the situation as a "threat" (Lazarus & Folkman, 1984; Seery, 2011). Building on the pioneering work of Lazarus and Folkman (1984), Blascovich and colleagues (Blascovich, 2008; Blascovich & Tomaka, 1996) introduced the BPS model to identify the physiological concomitants of challenge and threat, and to offer insight into the downstream consequences of challenge and threat appraisals for emotions, motivation, health, and well-being. In this paper, we take this research one step further to elucidate the effects of the "challenge" and "threat" physiological responses on creativity.

According to the BPS model, challenge and threat appraisals[5] are embodied physiologically and can be distinguished based on changes in the autonomic nervous system, which helps the body maintain homeostasis by reacting to internal and environmental demands. There are two primary physiological systems that form the foundation of the BPS model: the sympathetic-adrenal-medullary (SAM) system and the hypothalamic-pituitary-adrenal cortical (HPA) system. The SAM system is activated in situations evoking a fight-or-flight response (e.g., answering a difficult question during a speech in front of a large audience); the HPA system is more sluggish, activating and sustaining itself long after exposure to the initial stressor (e.g., reflecting on how well one answered the question). In response to an initial stressor, the hypothalamus can activate the SAM system, and the adrenal medulla (the inner part of the adrenal gland) releases adrenaline and noradrenaline. These hormones, in turn, spur increases in blood pressure and heart rate, induce pupil dilation, and inhibit the gastrointestinal tract.

This physiological fight-or-flight response (Cannon, 1932) is evolutionarily based as it helps mobilize the body to fight or flee from the threatening situation. Additionally, in response to a stressor, the hypothalamus can activate the HPA system, which directs the pituitary gland to release the adrenocorticotropic hormone (ACTH). This hormone then stimulates the adrenal cortex to release cortisol, which suppresses parts of the immune system. This physiological response can help mobilize energy resources in the face of a threatening situation by shutting down nonessential bodily functions. However, prolonged activation of the HPA system can lead to the development of chronic diseases, including hypertension and diabetes (Dickerson & Kemeny, 2004; McEwen, 1998). The SAM and HPA systems can activate independently or can co-activate; when co-activated, the two systems often function at different speeds. In a stressful situation, the SAM system can respond and reach its peak within seconds of stress onset and can turn off within seconds, facilitating a quick return to homeostasis. In comparison, the HPA system activates more slowly, taking minutes to reach its peak, and takes longer to return to homeostatic levels.

The SAM and HPA systems are relevant to our examination of bodily responses to stress and creativity because the BPS model considers "challenge" to be characterized by the activation of the SAM system and "threat" to be characterized by the activation of both the SAM and HPA systems. The BPS model relies on four cardiovascular measures associated with the SAM and HPA systems to distinguish between challenge and threat states: (1) heart rate

[4] Stress can also be induced by passive or goal-irrelevant performance situations, such as viewing a scary film (i.e., a situation that does not require instrumental cognitive responses and in which an adequate performance has no bearing on a person's well-being). However, these are considered low-arousal situations and are unlikely to generate the cardiovascular responses articulated in the BPS model (e.g., changes in cardiac output, total peripheral resistance, and ventricular contractility). Thus, we rely on the mood literature to make inferences about the relationship between stress induced by passive or goal-irrelevant situations and creativity (see De Dreu, Baas, & Nijstad, 2008).

[5] It is important to note that Blascovich and colleagues refer to "appraisals" as "evaluations," because they consider "appraisals" to connote more conscious processes and "evaluations" to capture the role of nonconscious processes in everyday behavior (Blascovich, 2008). To be consistent with Lazarus and Folkman (1984) and for consistency across the models of stress we compare in this paper, we will use the term "appraisals."

(how quickly the heart is pumping), (2) ventricular contractility (the force with which the heart contracts), (3) cardiac output (the measure of oxygenated blood processed through the heart per minute), and (4) total peripheral resistance (the amount of resistance that needs to be overcome to push blood through the circulatory system, or, alternatively, the overall constriction or dilation of the arterial system) (Blascovich & Mendes, 2010). The relative relationships among these four measures reflect the physiological differences between challenge and threat responses (see Table 1).

Because challenge and threat both involve active engagement during a motivated performance situation (e.g., giving a speech[6]), both are associated with increases in heart rate and ventricular contractility—one's heart beats harder and faster. However, challenge is uniquely characterized by increases in cardiac output and decreases in total peripheral resistance. In challenge states, the arteries dilate, which allows oxygenated blood to flow through the body quickly so that less effort is required from the heart. This same pattern of bodily responses is experienced when an individual is engaging in vigorous aerobic exercise (Wasserman & McIlroy, 1964). For these reasons, challenge is associated with more efficient or *fluid* cardiovascular responses.

In contrast, threat is characterized by little or no change in cardiac output and increases in total peripheral resistance. In a threat state, the body demands more oxygenated blood flow but the arteries remain constricted, and thus the heart must use more effort to pump blood throughout the body. This cardiovascular pattern is the same as that experienced when an individual freezes upon encountering potentially dangerous or harmful stimuli (Dienstbier, 1989). For these reasons, threat is associated with less efficient or *constrictive* cardiovascular responses. Notably, the link between challenge/threat appraisals (i.e., evaluation of resources and demands) and the challenge/threat physiological response profiles (i.e., fluid versus constrictive) have been well validated (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004).

Psychologically, challenge and threat are associated with different emotions and motivational orientations (Lazarus, 1991; Lazarus & Folkman, 1984). While challenge is related to greater approach orientation (e.g., leaning toward someone, openness; see Blascovich & Mendes, 2010), threat is associated with greater avoidance orientation (e.g., withdrawal, feelings of defeat), as highlighted in Table 1. Additionally, challenge is associated with approach-related, self-focused emotions (e.g., pride), while threat is related to avoidance-related, self-focused emotions (e.g., shame, anxiety; Blascovich, 2008; Blascovich & Mendes, 2010; Herrald & Tomaka, 2002; Mendes, Major, McCoy, & Blascovich, 2008).

In summary, the BPS model considers the physiological responses, emotions, and motivations associated with challenge and threat appraisals. In particular, challenge appraisals are associated with fluid physiological stress responses or "good stress" and physiological toughness (i.e., activation of SAM: increased heart rate, ventricle contractility, and cardiac output; decreased total peripheral resistance) (Dienstbier, 1989). Threat appraisals are associated with constrictive physiological stress responses or "bad stress" and physiological weakness (i.e., activation of both SAM and HPA: increased heart rate, ventricle contractility; no change in cardiac output; increased total peripheral resistance) (Blascovich, 2008; Blascovich & Tomaka, 1996; Dienstbier, 1989). As we will discuss in the next section, understanding these distinct physiological reactions to stress and accounting for them can enlighten organizational scholars' understanding of the effect of stress on creativity. Stressful situations give rise not just to cognitive changes but also to physiological ones. *Both* changes have the potential to shape creative output in organizational settings.

How Challenge and Threat Physiology Differentially Affect Creativity

Based on the BPS model, the key question we raise for organizational practice and scholarship on creativity is this: Do *physiological* challenge and threat responses differentially influence creative performance? Consistent with the idea that physiological responses offer additional explanatory power in the stress–creativity link, research suggests that challenge is generally associated with better cognitive performance (Akinola & Mendes, 2013; Mendes, Blascovich, Hunter, Lickel, & Jost, 2007; Mendes et al., 2008), while threat is associated with poorer cognitive performance (Blascovich & Mendes, 2010; Kassam, Koslov, & Mendes, 2009). Precisely how these two physiological responses divergently affect creative performance remains undetermined, but

[6] We use the example of giving a speech as a quintessential stress-inducing situation throughout this paper because it is widely accepted by the scholarly community as one that can engender challenge or threat physiology, depending on how the situation is appraised (Dickerson & Kemeny, 2004; Kirschbaum, Pirke, & Hellhammer, 1993).

TABLE 1
Physiological, Emotional, Motivational, and Behavioral Responses Associated With Challenge and Threat States

	Challenge	Threat
Appraisal	Resources exceed demands	Demands exceed resources
Physiological systems activated	Sympathetic-adrenal-medullary (SAM)	Sympathetic-adrenal-medullary (SAM) Hypothalamic-pituitary-adrenal (HPA)
Autonomic nervous system (ANS) reactivity	Increased heart rate Increased cardiac output Increased ventricle contractility Decreased total peripheral resistance	Increased heart rate No change in cardiac output Increased ventricle contractility Increased total peripheral resistance
Recovery from stressor	Quick return to homeostasis Quick cortisol reactivity	Slow return to homeostasis Slow cortisol reactivity
Emotions	Pride/high self-esteem	Shame/anxiety/low self-esteem
Motivational orientation	Approach/openness/leaning toward	Avoidance/withdrawal/defeat

they are likely to have differential effects on creativity for several reasons.

Preliminary evidence suggests that one reason challenge physiological stress responses can enhance creativity is that they increase cognitive flexibility, which is critical for generating novel and useful ideas (Lu, Akinola, & Mason, 2017; Lu, Brockner, Vardi, & Weitz, 2017; Lu, Hafenbrack et al., 2017). For instance, a study that experimentally manipulated challenge and threat (Akinola & Mendes, 2013) found that individuals exhibiting the challenge physiological profile performed better on a puzzle task requiring cognitive flexibility—that is, requiring participants to achieve creative insights by using broad and inclusive cognitive categories and flexibly switching among categories and approaches as defined by Nijstad, De Dreu, Rietzschel, and Baas (2010).

Indeed, activation of the SAM system (i.e., the challenge response) is purported to trigger the release of a moderate level of dopamine in prefrontal regions (Imperato, Puglisi-Allegra, Casolini, & Angelucci, 1991; Roth, Tam, Ida, Yang, & Deutch, 1988). This cortical area contains a large number of dopamine receptors (e.g., Goldman-Rakic, 1990), is highly sensitive to dopamine levels (Robbins, 2000), and is considered critical to the regulation of cognitive flexibility (Chudasama & Robbins, 2006; Ragozzino, 2007; for a review, see Klanker, Feenstra, & Denys, 2013).[7] At moderate levels, dopamine appears to enhance flexible responding. However, too much dopamine predicts impaired performance (Cools & D'Esposito, 2011; Cools, Sheridan, Jacobs, & D'Esposito, 2007).

Critically, SAM activation accompanied by HPA activation, which characterizes threat physiology, leads to the excessive release of dopamine in prefrontal regions (Deutch & Roth, 1991; Finlay, Zigmond, & Abercrombie, 1995; Goldstein, Rasmusson, Bunney, & Roth, 1996; Murphy, Arnsten, Goldman-Rakic, & Roth, 1996; Zahrt, Taylor, Mathew, & Arnsten, 1997). This may help explain why threat physiology would undermine creative performance. Other work suggests that challenge (versus threat) physiological responses may result in better creative performance because challenge physiology enhances cognitive stimulation of new ideas or solutions (Fink et al., 2010), heightens motivation (Blascovich & Mendes, 2010; Kassam et al., 2009), and provides more resources for creativity by boosting immunity and physiological thriving (Epel, McEwen, & Ickovics, 1998).

In sum, challenge and threat appear to be associated with distinct physiological responses. These states have discrepant effects on cognitive processes that are critical to creative performance (e.g., cognitive flexibility, cognitive stimulation, motivation, etc.; see Figure 2 for a process model). Organizational studies of stress might benefit from including bodily responses as a critical step in the causal pathway, because doing so offers greater specificity around how physiological and cognitive responses to stress work in concert to produce enhanced or impaired creativity. This knowledge of physiological processes elucidated by the BPS model in the context of creativity can help to (1) fill a theoretical gap in organizational models of stress by clarifying how stress can

[7] Precisely which aspect of the prefrontal cortices is involved varies depending on which type of flexibility is employed. Reversal learning (i.e., replacing a prepotent response with a new one) tends to involve aspects of the orbital frontal cortices (Clarke, Robbins, & Roberts, 2008; Dias, Robbins, & Roberts, 1996; McAlonan & Brown, 2003). Attentional-set and strategy-switching tend to involve the dorsolateral prefrontal cortex (Dias et al., 1996; Ragozzino, 2007; Sohn, Ursu, Anderson, Stenger, & Carter, 2000).

have positive and negative effects on creative performance, and (2) provide a potential explanation for the inconsistent findings in the organizational literature on the relationship between stress and creativity.

USING THE BPS MODEL TO RECONCILE DISPARATE FINDINGS IN THE CREATIVITY LITERATURE

A preponderance of evidence supports the negative effects of stress on creativity (e.g., Andrews & Smith, 1996; Drwal, 1973; Eysenck, 1995; Kelly & McGrath, 1985). For instance, studies have shown a negative relationship between common stressors such as time pressure on both the amount of creative output (Kelly & McGrath, 1985) and the overall creativity of ideas (Andrews & Smith, 1996). The primary mechanism explaining these negative effects is the depletion of cognitive and emotional resources (Byron et al., 2010).

However, stress has also been shown to positively predict creative performance by increasing motivation (Ohly & Fritz, 2010) and arousal or energetic activation (De Dreu, Baas, & Nijstad, 2008; Kapadia, 2016). For instance, several studies suggest that time pressure—which is largely perceived as a stressor—may have a positive (Ohly & Fritz, 2010) or curvilinear (Baer & Oldham, 2006) relationship with creativity. Further, there is empirical evidence based on the Yerkes-Dodson law of arousal (Yerkes & Dodson, 1908)[8] suggesting that creativity is enhanced at moderate levels of stress but impaired when stress levels are too low or too high (Baer & Oldham, 2006).

These mixed findings suggest the need for additional perspectives on the relationship between stress and creativity in organizational research. While it is possible that these mixed findings are due to methodological differences across studies (e.g., Aguinis & Vandenberg, 2014), such as different time lags between measures of stress and creativity or different measures of creativity, they raise the question of whether these differences can be explained theoretically and practically by measuring physiological responses.

The BPS model can help address these disparate findings in two ways: (1) providing a coherent physiological account for the positive and negative effects of stress on creativity, and (2) providing the opportunity to empirically measure challenge/threat physiological responses without the drawbacks of self-report, as discussed earlier. The BPS model suggests that one way to explain why a particular stressor can enhance creativity is that it engenders challenge physiological responses that facilitate cognitive flexibility, approach motivation, and psychological thriving, all of which help generate creative thinking. On the other hand, certain stressors can induce threat physiological responses, depleting cognitive resources and flexibility and impairing creativity. Thus, implicating physiological stress responses provides a novel perspective on the relationship between stress and creativity.

ORGANIZATIONAL MODELS OF STRESS AND THEIR IMPLICATIONS FOR CREATIVITY

Given that we argue that adding physiological responses to the causal pathway linking stress and creative performance can help explain the discrepant findings (i.e., positive, negative, and curvilinear), it is important to review traditional stress models. Organizational literature has relied primarily on three traditional stress models to explain the effects of stress on performance outcomes: the conservation of resources model (Hobfoll, 1989), the transactional model of stress (Lazarus & Folkman, 1984), and the challenge stressor–hindrance stressor framework (LePine, LePine, & Jackson, 2004). Importantly, none of these traditional models of stress has been constructed to explain or examine how stress affects creativity. In the following sections, we provide an overview of each model, highlight how each model relates to the BPS, and discuss the implications of each model for organizational creativity.

The Conservation of Resources (COR) Model

Overview of the COR model. The COR model argues that individuals strive to conserve their resources and acquire additional resources in all circumstances (Hobfoll, 1989; Hobfoll, Halbesleben,

[8] The Yerkes-Dodson law is often discussed as it relates to social facilitation (Zajonc, 1965), with the presence of others serving as a source of arousal that heightens performance on well-learned tasks and hinders performance on unlearned tasks. Consistent with this theorizing, research examining social facilitation in the context of the BPS model has found that those performing well-learned tasks in the presence of others experienced challenge physiological responses, while those performing unlearned tasks in the presence of others experienced threat physiological responses (Blascovich, Mendes, Hunter, & Salomon, 1999).

Neveu, & Westman, 2018). Thus, the threat of losing resources is the primary source of stress in the workplace (Hobfoll, 1989). Resources, broadly defined, may include objects, conditions, personal characteristics, and "energies" such as time, money, and knowledge that are valuable to the individual (Hobfoll, 1989). A major tenet of COR theory is the *primacy of resource loss*, which states that the experience of losing resources is more psychologically powerful than the experience of retrieving lost resources (Halbesleben, Neveu, Paustian-Underdahl, & Westman, 2014; Hobfoll, 1989). Another major tenet of COR theory is *resource investment*, which states that individuals invest resources to gain resources, prevent resource loss, and recover from resource loss.

The COR model recognizes that individuals differ in their capabilities to manage resource loss and gain, depending on their initial levels of resources. Individuals who already hold resources are in a better position to gain more, whereas those with few resources may experience greater resource loss and adopt defensive approaches to conserve remaining resources, leading to resource loss spirals in which one's initial resource level predicts one's resource trajectory (Halbesleben et al., 2014; Hobfoll, 2001). For example, personality traits reflecting an active and efficient coping style, such as optimism and self-efficacy, are among the key resources that help an individual implement and mobilize other resources for effective use (e.g., Hobfoll, 2002; ten Brummelhuis & Bakker, 2012). Several empirical studies offer support for the major tenets of the COR model (e.g., Halbesleben, 2006; Lee & Ashforth, 1996), and importantly, suggest that the stress caused by a loss of resources negatively influences creativity (Amabile & Conti, 1999).

Comparison between the COR and BPS models. How then does the COR model relate to the BPS model? First, the resource loss identified in the COR model is aligned with threat states in which demands are appraised as exceeding resources in the BPS model. Also, COR suggests that people strive to build resources to recover from resource loss (e.g., strengthening skills during respites), which has the potential to lead to a net gain of resources; there can be resource gain spirals, in which individuals who have high levels of initial resources (e.g., knowledge, social support) are better positioned to gain new resources (Halbesleben et al., 2014; Hobfoll, 1989, 2002).

The theorizing about resource gains in the COR is consistent with how challenge states are conceived in the BPS model. Notably, while the COR model assumes that individuals need to invest a small amount of resources to gain a larger amount to prevent resource drain, it is unclear whether and how such processes take place. The BPS model fills this theoretical gap by suggesting challenge physiological responses as a critical mechanism through which individuals gain greater resources (e.g., working memory, cognitive flexibility, and emotions such as pride) that can ensue organically from experiencing adaptive physiological responses (e.g., increased cardiac output, decreased total peripheral resistance). Thus, the BPS model suggests that challenge physiological responses may be a mechanism that induces resource gains articulated in the COR model.

Second, while the COR model identifies several key resources (e.g., self-esteem, optimism) that can mobilize other resources in stressful situations, the BPS model offers a potential explanation for how these key resources may operate through internal biological systems (i.e., adaptive cardiovascular and neuroendocrine responses). For example, there is evidence that individuals with stable, high self-esteem exhibit challenge physiological profiles after receiving failure performance feedback, whereas individuals with stable, low self-esteem exhibit threat physiological profiles (Seery, Blascovich, Weisbuch, & Vick, 2004). Thus, the BPS model builds on the findings of the COR model by identifying physiological responses as a mechanism through which the negative effects of resource loss can be exacerbated (i.e., through threat physiological responses) or reversed (i.e., through challenge physiological responses).

Implications of the COR and BPS models for creativity. The COR model argues that people will strive to gain or conserve their resources, and failure to prevent actual loss or to minimize the threat of losing important resources will lead to stress. This argument suggests that one's current resource capacity will help predict how these resources are expended toward creative performance. For example, if one is in a positive mood, more energy will be channeled toward the creative task as the positive mood may signal an abundance of resources. The COR model may even predict that this energy will lead to a resource gain spiral if one enjoys the creative task, thereby further increasing positive mood and creative performance.

However, if one is low in resources, one may put forth fewer resources toward that creative activity and may actually experience a resource loss spiral. For example, if individuals feel that they lack a critical resource, such as sufficient knowledge to adequately brainstorm ideas, they may become unwilling to share their preliminary ideas. As a result, they may be less likely to receive valuable feedback from others, which can hinder their creativity. Counter to the perspective articulated in the COR model that the initial perception of one's resources will predict future resource gain or loss spirals, the BPS model argues that a person's perception of available resources will trigger challenge or threat physiological responses. Thus, it is the emotions, motivations, and cognition associated with each physiological response pattern that will influence creative performance in organizational settings.

The Transactional Model of Stress

Another important organizational stress model—the transactional model of stress (Lazarus & Folkman, 1984)—contextualizes our argument that examining stress from a physiological perspective can further scholars' understanding of the relationship between stress and creativity in organizations.

Overview of the transactional model of stress. In the transactional model of stress, stress is defined as the "relationship between an individual and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (Lazarus & Folkman, 1984, p. 21). However, the focus of the transactional model of stress is not the objective level or features of threatened resources, but rather the individual's appraisal of both the importance of the task at hand and his or her ability to meet the demands of the task. In the transactional model, the primary appraisal evaluates the potential harm or benefit inherent in the situation, while a secondary appraisal—a complex evaluative process—considers what coping strategies are available, how appropriate they are for managing the task, and whether the individual's resources will be effective in applying them (Lazarus & Folkman, 1984).

Comparison between the transactional model of stress and the BPS model. The transactional model of stress and the BPS model share the same starting point: appraisals of resources and demands. However, in the transactional model these appraisals directly affect task performance, whereas in the BPS model appraisals trigger physiological responses that in turn affect task performance (see Table 2). For example, consider a situation in which an individual appraises a situation (e.g., giving a speech) as important, but perceives himself or herself as having the resources to cope. According to the transactional model, a second appraisal process, which involves a search for coping strategies to tackle the task at hand, would then occur. According to the BPS model, appraising the important situation as one for which the individual has sufficient resources triggers a challenge physiological response (e.g., increases in cardiac output, decreases in total peripheral resistance), which in turn increases attention to the task at hand (Hancock & Weaver, 2005), augments the efficiency with which information is processed, and enhances memory for the task, all of which would likely be beneficial for task performance (Cahill, Gorski, & Le, 2003). Perceiving oneself as lacking the resources needed to cope with the situation at hand would, according to the BPS model, trigger a threat response that would likely hinder task performance.

TABLE 2
Comparisons Between Traditional Theories of Stress in Organizational Research and the Biopsychosocial Model of Challenge and Threat

	Conservation of resources model	Transactional model of stress	Challenge stressor–hindrance stressor framework	Biopsychosocial model of challenge and threat
Focus of analysis	Level of resources	Person–environment relationship in light of goal-relevant demands and resources	Features of stressors	Physiological state
Stress as challenge and/ or threat	Challenge and threat	Challenge and threat	Challenge and threat	Challenge and threat
Flexibility of appraisal	Not present or unimportant	Moderately flexible; based on subjective evaluation of demands and resources	Highly inflexible; universal pattern of responses to certain types of stressors	Highly flexible; contingent on intrapersonal/ interpersonal factors
Measure of challenge/ threat	No measure of challenge/threat state	Self-report scale	No measure of challenge/ threat state	Objective measure of challenge/threat using physiological responses

Implications of the transactional model of stress and the BPS model for creativity. The transactional model of stress predicts that an individual facing a creative task will first appraise whether engaging in the creative task is likely to be beneficial or harmful. Following that primary appraisal, the individual's secondary appraisal will determine what resources are available for the task and whether he or she will be effective in directing those resources toward the task at hand. For example, if an individual is facing a problem that demands creativity, he or she will first determine whether the situation is likely to be beneficial or harmful, based on his or her stake in the situation at hand (Lazarus & Folkman, 1987). Following this primary appraisal, he or she will engage in a secondary appraisal, deciding how to tackle and overcome the creative problem. For example, when living abroad, individuals who have sufficient resources (e.g., social support) may appraise this novel experience as a challenge rather than a threat, and thus when facing a situation that demands creativity will exhibit higher creativity (Lu, Martin, Usova, & Galinsky, 2019; Lu, Quoidbach, et al., 2017).

By contrast, according to the BPS model, the primary appraisal will trigger challenge or threat physiological responses. Once triggered, the emotions, motivations, and cognitions associated with each physiological response pattern will affect how the creative problem is approached and tackled. Thus, the decision of how the problem is tackled is influenced primarily by physiological responses according to the BPS model, not by secondary appraisal as is the case with the transactional model of stress.

The Challenge Stressor–Hindrance Stressor Framework

The final organizational stress model that highlights how examining stress from a physiological lens can enrich organizational scholarship on creativity is the challenge stressor–hindrance stressor framework.

Overview of the challenge stressor–hindrance stressor framework. The challenge stressor–hindrance stressor framework argues that workplace stressors can be classified as either challenges or hindrances and will have either positive or negative effects on attitudes and performance depending on how the stressor is appraised (LePine et al., 2004; LePine, Podsakoff, & LePine, 2005). Appraisals of stressors in this framework affect the coping strategies individuals employ to manage the stressor—specifically, whether they employ problem-solving strategies or avoidance strategies (LePine et al., 2004, 2005). Challenge stressors include factors such as time pressure, heavier workload, and increased responsibility, while hindrance stressors include factors such as politics, role conflict, and role ambiguity (e.g., Cavanaugh, Boswell, Roehling, & Boudreau, 2000). Thus, the challenge stressor–hindrance stressor framework incorporates expectancy theory (Vroom, 1964) to classify challenge stressors as those likely to lead to successful outcomes if appropriate effort is expended and hindrance stressors as those unlikely to lead to successful outcomes regardless of the effort an individual exerts (LePine et al., 2005).

Comparison between the challenge stressor–hindrance stressor framework and the BPS model. Despite the similarities between the challenge stressor–hindrance stressor framework and the BPS model in terms of articulating both positive and negative types of stress, substantial differences exist between these two theoretical perspectives. First, the units of theoretical focus are different. The challenge stressor–hindrance stressor framework focuses on the *types* of stressors (i.e., hindrance or challenge), which are assumed to have *uniformly* positive or negative effects on individuals' stress levels. In contrast, the BPS model focuses less on types of stressors and instead presents an *individualized response* perspective in which a given situational stressor (e.g., time pressure) may have varying effects on different individuals.

The BPS model acknowledges that a given stressor may induce a challenge physiological response in which cardiovascular reactivity reflects an efficient, adaptive use of energy in some individuals and induce a threat physiological response in which energy is inefficiently used in other individuals (Blascovich, 2008; Blascovich & Tomaka, 1996). Whereas the challenge stressor–hindrance stressor model focuses on *situations* that cause stress and assumes that they do so uniformly, the BPS model focuses on how a *person* responds to a potential source of stress. Moreover, the challenge stressor–hindrance stressor framework suggests that stressors, regardless of whether they are challenging or hindering, all lead to increased levels of strain (LePine et al., 2005), while the BPS model suggests that threat physiological responses are *uniquely* related to increased strains and challenge physiological responses are related to reduced strains.

Implications of the challenge stressor–hindrance stressor framework and the BPS model for creativity. The challenge stressor–hindrance stressor model argues that certain stressors increase creativity by positively influencing people's expectancy that effort will yield successful outcomes, while other stressors decrease creativity by hindering people's expectancy that effort will yield successful outcomes. Thus, in this model, a stressor such as a heavy workload may lead to higher creativity if it is appraised as a challenge, inducing coping strategies that motivate people toward a successful creative outcome. In contrast, a stressor such as role conflict may decrease creativity because individuals may become demotivated if they believe that the effort they expend will not lead to a successful creative outcome.

In contrast, the BPS model is agnostic about stressor types and their potential influence on creativity. Rather, the BPS model argues that for some individuals, a stressor such as time pressure can result in a threat appraisal and thus threat physiological responses, which may hinder creative performance by narrowing attentional focus, reducing working memory, and impairing cognitive functioning (e.g., Chajut & Algom, 2003; Kirschbaum, Wolf, May, Wippich, & Hellhammer, 1996). Yet for others, this same time pressure could result in a challenge appraisal and thus challenge physiology responses, which may promote abstract thinking, cognitive flexibility, and information processing (Baddeley, 2000; Damasio, 2001), all of which can enhance creativity.

Summary of Organizational Models of Stress and Implications for Creativity

Taken together, the three organizational models of stress we have profiled all identify stress as involving some form of appraisal of the demands and resources in a given situation. In the COR model, although appraisal is not a formal component, the initial perception of one's resources will determine future resource gain or loss spirals. The transactional model explicitly describes the need for a secondary challenge appraisal to induce successful coping strategies necessary for creative success. In the challenge stressor–hindrance stressor framework, it is assumed that challenge stressors are appraised in a way that motivates people to respond with problem-solving strategies, whereas hindrance stressors are appraised in a way that directs to avoidance strategies.

The BPS model differs from and complements these theories of stress in multiple ways (see Table 2). First, the theoretical foci of these models differ. The COR model focuses on the level of resources an individual has and considers stress to ensue from the threat of losing resources or from the actual experience of losing resources. The transactional model of stress focuses on the relationship between the person and relevant aspects of the environment and posits that stress will ensue when the environment becomes taxing due to insufficient resources. The challenge stressor–hindrance stressor framework focuses less on when stress will ensue and more on features of stressors that dictate whether the stressor will harm or help an individual's performance. In comparison, the BPS model focuses on the physiological stress responses that ensue depending on how individuals evaluate their demands and resources in a given situation. We argue that this physiological perspective is beneficial for organizational studies of creativity as it highlights overlooked biological factors (i.e., challenge and threat cardiovascular and hormonal responses) that can influence creative performance.

Second, existing theories of stress in organizational studies suggest that individuals' resources, the types of stressors they might face, their appraisals, and their physiological reactions to stress are predetermined and relatively inflexible. For instance, if one is experiencing a hindrance stressor and does not have adequate resources to cope with it, then one is highly likely to deploy an ineffective coping strategy and experience a constrictive physiological state, which will ultimately harm creativity. In the COR model, this person is further predisposed to experiencing a vicious spiral of resource loss and worsened outcomes. While the COR model also considers the situation of resource gains, it focuses more on the primacy of resource loss and states that resource gain is conditioned by the initial level of resources. In contrast, the BPS model integrates important components from the COR model, the transactional model of stress, and the challenge stressor–hindrance stressor framework with insights from the physiological effects of stress on the body to argue that stress has the potential to be beneficial for creative performance when coupled with adaptive, fluid (i.e., challenge) physiological responses.

Third, from the perspective of measuring stress, existing theories of stress in organizational studies often rely on subjective measures of challenge and threat appraisals that are based on individuals' self-reports of the demands and resources they experience in a given stressful situation. As mentioned earlier, one issue with these subjective measures is that they can be easily influenced by self-report biases. In contrast, the BPS model relies on objective, physiological measures of stress that are difficult, if not impossible, to control, and are therefore less susceptible to social desirability artifacts (Akinola, 2010; Blascovich & Mendes, 2010). This objective measurement of physiological responses in the context of stress has implications for organizational research on creativity as it offers a potential mechanistic perspective for why studies have shown that stress can have positive, negative, and curvilinear effects on organizational creativity.

IMPORTANT CONSIDERATIONS IN MEASURING PHYSIOLOGICAL RESPONSES IN ORGANIZATIONS

This paper advances the perspective that organizational scholars tend to skip an important step in the causal pathway between stress and creativity—physiological responses—and that adding this step to the causal chain would offer additional explanatory power. Of course, a skeptic might ask a few questions: If challenge and threat appraisals have distinct, reliable physiological markers, why bother measuring them at all? Do we really gain explanatory power by assessing the body's reactions to stressors? Is it not sufficient to ask people whether they perceive themselves as having the resources required to meet the demands of a situation (to measure their appraisal of the stressor)? Our view is that there is much to be gained theoretically and practically from directly measuring and accounting for physiological responses to stress. The promise of physiological responses is in the two advantages they offer over self-report: reliability and sensitivity.

The main rationale for using physiological measures in organizational research on creativity is that they can offer insights that are often unable to be captured solely by traditional measures such as self-report and behavioral observation (Akinola, 2010). Indeed, research in disciplines including economics (Camerer, Loewenstein, & Prelec, 2005), neurobiology (Gunnar & Quevedo, 2007), and social psychology (Akinola & Mendes, 2013; Blascovich & Mendes, 2010) has offered convergent evidence that physiological responses predict individuals' preferences and attitudes before these preferences can even be articulated (Bechara, Damasio, & Damasio, 2000; Bechara, Damasio, Tranel, & Damasio, 1997), and in some cases more reliably predict behavior than self-report measures (Akinola, 2010; Josephs et al., 2006). Thus, one key benefit of integrating physiological responses into creativity research is that they provide another angle through which to understand participants' attitudes and behaviors, especially those that are typically subject to social desirability artifacts (Blascovich & Mendes, 2010).

While scarce, there is also some promising research using physiological measures in organizations that offers insight into their reliability and sensitivity. For instance, a study of police officers showed that there are physiological benefits of having high status (Akinola & Mendes, 2013). Police officers with higher social standing had more adaptive stress responses reflected by greater increases in cardiac output and heart rate reactivity (relative to those with lower status) during a stress test, thus demonstrating that status can be good for one's health, an insight previously assumed and not assessed. Further, research examining hormone levels in organizational environments, or among MBA students, has highlighted important relationships between hormones such as cortisol and testosterone and key organizational outcomes. For example, there is evidence that traders with higher waking testosterone levels make more money than those with lower levels (e.g., Coates & Herbert, 2008), managers have lower cortisol levels relative to nonmanagers (Sherman et al., 2012), and groups with the collective hormonal profile of high testosterone and low cortisol outperform other groups in group decision-making tasks (Akinola, Page-Gould, Mehta, & Lu, 2016).

Importantly, several of these studies included both self-reports of stress and physiological measures and found a lack of correspondence. These findings underscore the importance of incorporating both physiological and psychological responses into organizational research to better understand how stress affects creativity, provided that the benefits and insights far outweigh the costs. Nonetheless, it is important to consider the costs and challenges of using physiological equipment in studying phenomena such as organizational creativity.

Cost Considerations

The major costs to consider in utilizing physiological measures in organizational research include the cost of the equipment and the cost of assaying saliva to determine hormone levels (e.g., cortisol measured via saliva).

Physiological equipment. While the majority of studies using physiological equipment have been conducted in psychology laboratories, many business schools have begun to incorporate physiological equipment into their behavioral research labs. Moreover, recent advances in technology have led to the development of noninvasive ambulatory equipment capable of measuring the key metrics associated with challenge and threat physiological responses, namely cardiac output (Henry et al., 2011) and total peripheral resistance (Haslam, Gordhandas, Ricciardi, Heldt, & Verghese, 2011). For instance, the Vrije Universiteit Amsterdam has developed a small device (i.e., VU-AMS) that can be worn on a belt during a person's workday. Though costly (currently ranging from US$5,000 to $6,000), this device tracks the key measures that capture challenge and threat physiological responses wirelessly, second by second, and is ripe for use in field research on stress and creativity in organizations.

Additionally, bio-sensing trackers such as the Empatica E4 watch can capture physiological responses such as heart rate and electrodermal activity (i.e., activity of the sweat glands). This tracker can indicate general arousal or anxiety, attention, and emotion intensity in the context of stress, and has been used successfully in experience sampling research in academic and commercial spheres (Picard, Fedor, & Ayzenberg, 2016). Further, advances in health care have resulted in the development of equipment that can monitor patients outside of hospital settings (e.g., Kinnamon, Ghanta, Lin, Muthukumar, & Prasad, 2017). As the commercial demand for bio-sensing technology increases, it is likely that the costs for high-quality equipment will continue to decline, making it easier for researchers to collect these measures in organizations.

Hormone assays. Hormones are commonly measured in organizational employees through the collection of saliva, which is more accessible than other bodily fluids (i.e., urine and blood) and is conducive to experimental research designs (Page-Gould & Akinola, 2015). Another noninvasive way to measure hormones is to collect hair samples, which can be assayed for cortisol and capture chronic stress levels (Russell, Koren, Rieder, & Van Uum, 2012; Stalder & Kirschbaum, 2012). There are many advantages of using hair samples, as hair grows at a steady rate (1 cm per month; Wennig, 2000), can be stored easily, is unaffected by the sampling procedure (Gow, Thomson, Rieder, Van Uum, & Koren, 2010), and enables scholars to sample during salient periods (e.g., through an organizational change), to assess stress levels retroactively. To date, hair cortisol has been used in organizational studies to investigate the chronic stress of unemployment (Dettenborn, Tietze, Bruckner, & Kirschbaum, 2010) and to examine changes in followers' stress levels in response to leadership behaviors (Diebig, Bormann, & Rowold, 2016).

The major costs associated with assessing hormones through saliva or hair are purchasing assay kits and having samples assayed by specialized laboratories (e.g., Salimetrics, Dresden LabService). For saliva, these costs range from US$5 to $10 per participant per hormone. Hair analysis costs range from US$30 to $35 per hair sample. However, for researchers at universities with medical schools, collaborations can be established so that saliva or hair can be assayed at a much lower cost than at specialized laboratories.

In sum, while the costs of equipment and hormone assays may be substantial depending on the size and scope of the study, individuals are increasingly receptive to taking their own physiological measurements, potentially offsetting the cost of paying individuals to participate in studies examining physiological stress responses. For instance, organizations such as the Quantified Self (quantifiedself.com) offer communities of individuals who regularly track their own physiological responses and are receptive to participating in research. Further, organizations developing new bio-sensing trackers are often eager to have their technologies tested in research for free or at discounted prices. Additionally, the growing interest in stress and its effects in organizations has made companies receptive to conducting research that can meaningfully influence how stress is experienced in the workforce (Porter, 2015). Thus, collaborations may provide a fruitful, cost-effective avenue for studying stress and creativity in organizations.

Finally, we would be remiss not to point out that there has historically been tremendous confusion about the role that stress plays in creativity—numerous scholars have spun their proverbial wheels trying to make sense of findings that, on the surface, seemed contradictory. Going forward we might be able to limit some of this confusion and wheel-spinning by investing financial resources in getting a clearer empirical picture. Doing so would arguably save resources in the long run.

Study Design Considerations

The majority of research on physiological stress responses has examined acute, episodic stress experiences (e.g., an individual is giving a speech or engaging in a salary negotiation; Akinola, Fridman, Mor, Morris, & Crum, 2016; Akinola & Mendes, 2008; Brown & Curhan, 2013). Organizational environments are replete with episodic stressors, making this context valuable for understanding how these episodes of stress can influence creativity. However, it is equally important to develop an understanding of the cumulative effects of episodic stress on creativity, which warrants longitudinal study designs. Such longitudinal studies could include daily ambulatory monitoring of physiological responses, as well as daily measurements of emotions and behavior assessed through experience sampling methodologies (e.g., Fraley & Hudson, 2013). Moreover, it is potentially easier and more reliable to test cumulative and long-term effects of stress by obtaining momentary, unobtrusive measures of physiological responses than by asking people how stressed they are every five minutes, which is prone to self-report bias. These longitudinal studies require a keen awareness and sensitivity to the timing and duration of physiological measurements to ensure that the metrics collected are aligned with the theoretical and practical goals of the research (Bolger, Davis, & Rafaeli, 2003; Bolger & Laurenceau, 2013; Shipp & Cole, 2015).

Additionally, study designs can be employed to examine how physiological responses to stress affect creativity in intensive organizational creativity tasks. For instance, many companies now organize hackathons in which employees generate creative solutions to technology problems under time pressure. One research question emanating from this common organizational practice is how stress affects creative performance in hackathons. Hackathons are intentionally conducted under time pressure, but the duration can vary from 12 hours to 72 hours (Bourque, 2017). In a study like this, hackathon timing could be manipulated either within or across teams. Employees' cardiovascular responses could be measured using ambulatory devices (i.e., watches or more advanced equipment such as VU-AMS devices). Hormonal responses, such as cortisol and testosterone, could be measured at regular intervals throughout the hackathon (e.g., start, midpoint, end; every four hours), with assessments of emotions and appraisals (i.e., via experience sampling using employees' smartphones) at the same intervals, at random, or on an episodic basis (Reis & Gable, 2000; Wheeler & Reis, 1991). This breadth of measures would allow for triangulation across methodologies to examine how well different physiological responses predict creative performance.

Researchers could also use these measures to design studies exploring the relationship between physiological responses to stress and creativity in daily work life. Such studies could involve daily ambulatory monitoring of physiological responses as well as daily measurements of emotions and behavior, assessed through experience sampling methodologies (e.g., Bolger et al., 2003; Csikszentmihalyi & Larson, 2014). It is important to note that studies capturing the stress of real work conditions need not have exceptionally long durations but could instead capture an employee's typical week. For example, Coates and Herbert (2008) measured the hormone levels of 17 stock traders over eight days, with saliva samples taken twice per day.

Other research designs could focus on exogenous stressors that span a longer period of time, such as a change in management or planned layoffs. Research questions can center around how such exogenous stressors can affect creativity in organizations via physiological stress levels at different time points. In such contexts, physiological measures would be taken at specified time points prior to the exogenous stressor (e.g., prior to the announcement of a change in management) and specified time points following the stressor (e.g., important milestones as the change unfolds). To study less predictable exogenous stressors, researchers can adopt event-contingent longitudinal designs, in which participants are assessed every time a predefined event (e.g., stock market volatility) has taken place (Bolger & Laurenceau, 2013; Shiffman, Stone, & Hufford, 2008).

Finally, future research designs could also consider studying how stress affects different types of creativity, such as state- and trait-level creativity, divergent or convergent thinking, or the stage at which creativity is taking place (e.g., idea generation, evaluation, and implementation stages). For example, when studying creative traits, researchers can examine whether individuals with higher trait-level creativity are more likely to appraise situations as challenging and exhibit challenge physiological responses. Another intriguing study design is to measure physiological responses throughout specific creativity phases to examine the role of threat at different stages of the creativity process. For instance, threat responses may be more detrimental during early stages of idea generation and evaluation as they may limit divergent thinking by narrowing attentional focus; however, threat responses may be valuable during implementation stages, when such narrowed attentional focus could facilitate persistence in the execution of ideas generated.

As with any research, significant attention needs to be paid to the design of studies that use physiological measures to examine how stress affects creativity in organizations. As noted earlier, the use of these measures is likely to be more valuable in contexts where self-report bias is prevalent, as physiological measures may provide crucial information that cannot be obtained through traditional assessments.

DISCUSSION

We offer a new perspective on the relationship between stress and creativity by highlighting an important factor that has been overlooked by organizational scholars: physiological responses to organizational stressors. We argue that how individuals respond to stress-inducing situations matters for creativity. After illustrating the theoretical benefits of examining the role of stress through the BPS model, we presented practical information for scholars to incorporate physiological measures in organizational research. In the following sections, we discuss the implications of our perspective for organizational theory, research, and practice.

Theoretical Implications

We contribute to organizational theory on creativity by providing greater clarity and precision in theorization. First, we articulate the physiological processes that can dictate whether and how stress can enhance or impair creativity. By introducing an overlooked causal pathway between stress and creativity through physiological responses, we offer a novel perspective to reconcile the divergent effects of stress on creativity (e.g., positive, negative, curvilinear), thus enhancing theoretical clarity. To date, theoretical perspectives on the psychophysiology of stress have rarely crossed paths with the creativity literature. Here we begin to bridge the gap between these two research areas.

Second, we integrate physiological research with existing theories of stress, not only demonstrating how physiological models of stress can contribute to organizational theories of stress, but also exploring how individuals' physiological responses to stress can affect creativity. While traditional stress theories focus on minimizing and managing stress, or classifying stressors by type (e.g., beneficial or harmful), our perspective is that even seemingly harmful stressors can positively influence creativity if they are perceived and experienced in a way that generates a challenge physiological response. As a result, our theoretical perspective increases the precision in theorizing the relationship between stress and creativity.

Research Implications

The theoretical perspective we have advanced presents numerous avenues for future research. While we have mentioned several future directions in the study design consideration section above, additional avenues abound. For instance, recent technological advancements now allow researchers to track individuals' moment-to-moment physiological responses and incorporate experience sampling methodologies that allow individuals to simultaneously report their emotions and cognitive functioning. These methodologies will be helpful for future experimental investigations of the relationship among stress, creativity, and well-being.

Future research can measure physiological stress responses associated with the stressors typically used in creativity research (e.g., time pressure) to examine the physiological properties of these stressors and explore how interventions may moderate these relationships. For example, it may be interesting to explore the circumstances under which stressors such as time pressure generate challenge or threat physiological responses (e.g., by testing if and when a stressor, as proposed in the challenge stressor–hindrance stressor framework, is objectively experienced as challenging or threatening in the body). Further, experiments manipulating physiological stress responses and examining their effects on cognitive functioning related to creativity would help deepen scholars' understanding of how physiological and cognitive processes work together to influence creativity in organizations.

Additionally, future research should explore questions related to how stress-induced creativity in organizations can influence individual health and well-being in the short and long term. Epidemiological research suggests that beneficial responses to stress may confer long-term health benefits. For instance, more approach-oriented physiological reactivity to stress, such as the reactivity engendered through challenge, can minimize the cumulative "wear and tear" on the body's cardiovascular system, resulting in fewer incidences of diabetes, hypertension, and cardiovascular disease (McEwen, 1998). In contrast, key cardiovascular markers of threat physiology have been linked to a greater risk of Alzheimer's disease and accelerated brain aging (Jefferson et al., 2010). This evidence suggests that in addition to providing short-term cognitive and physiological benefits, experiencing stressors as a challenge may also protect individuals against detrimental long-term health outcomes. Therefore, longitudinal studies with repeated daily assessments of physiological stress responses that also track employees' creative performance may shed further light on how stress-induced creativity can affect employees' long-term health and well-being.

Another avenue for future research is examining the roles stress and physiology play in group-level creativity. A recent study found that dyads with synchronized nonverbal behavior exhibited greater dyadic creativity (Won, Bailenson, Stathatos, & Dai, 2014). Further, there is evidence that collective hormonal profiles (e.g., high testosterone and low cortisol) can influence group performance (Akinola, Page-Gould et al., 2016). Therefore, it is possible that collective physiological responses may influence the creative performance of a group. Additionally, physiological reactivity can be contagious, such that when mothers experience physiological threat responses, these responses get passed on to their infants (Waters, West, & Mendes, 2014). Whether this type of physiological contagion extends to groups in organizational settings, and whether it can influence group-level creativity, warrant future investigation.

Practical Implications

Organizations continue to look for ways to increase the creative performance of employees. By implicating challenge (vs. threat) physiological responses as a previously overlooked mechanism in the link between stress and creativity, this paper offers new avenues through which organizations can intervene to improve creativity. Central to this premise is educating employees that not all stress is harmful and that some stress can actually be beneficial to performance (Blascovich, 2008; Blascovich & Tomaka, 1996). This perspective is one that runs counter not only to lay beliefs about the effects of stress but also to traditional theories of stress in organizations, in which stress is thought to inhibit performance (e.g., McGrath, 1976). Indeed, research on stress mindset has demonstrated that individuals' perceptions of stress can affect whether they experience positive or negative health outcomes from stress (Crum, Salovey, & Achor, 2013), and that changing these perceptions may serve as a catalyst that helps individuals experience physiological stress responses in ways that enhance performance.

CONCLUSION

We have articulated a perspective that takes into account bodily reactions to stress in an effort to deepen scholarly knowledge about the relationship between stress and creativity. We have also provided considerations for scholars interested in researching physiology as it relates to stress and creativity in organizations. Although much remains to be explored, we are hopeful that the perspective we advance helps generate new insight about how to enhance creativity in organizations. Moreover, we hope we have helped motivate researchers to consider employing innovative approaches to capture physiological stress responses in organizational settings.

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