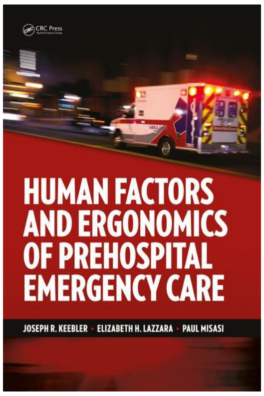

Human Factors and Ergonomics of Prehospital Emergency Care
Critical Essays in Human Geography

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Stress and Performance in Emergency Medical Services

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5 Stress and Performance in Emergency Medical Services

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CONTENTS

Stress is ubiquitous in modern work, and its effects can be costly in terms of performance and health as well as in public safety and well-being. There is clear evidence that the stress associated with EMS work incurs such costs (e.g., Cydulka et al., 1989; Marmar et al., 1996; Holland, 2011; Donnelly, 2012; Halpern et al., 2012) and that the stress can be acute or chronic (Halpern & Maunder, 2011; Adriaenssens et al., 2015). In addition, stressful events tend to be characteristics of the specific contexts or situations in which they occur (e.g., the patient, bystanders, dangerous conditions), organizational factors (e.g., staff shortages, lack of training or resources, perceived unfairness in the distribution of responsibilities; Donnelly et al., 2014), and characteristics of the person (e.g., general life or work stress; feelings of helplessness; Halpern et al., 2012). In this chapter, I provide an overview of the stress construct, theories of stress, potential avenues for mitigation, and gaps in our understanding of stress and human performance. The issues discussed are relevant across most work domains but specifically germane to the contextual and task factors that affect the performance and well-being of EMS personnel.

THE STRESS CONSTRUCT: DEFINITION AND THEORY

Current definitions of stress are characterized by cognitive and physiological response to environmental demand (Hockey, 1984, 1986, 1997; Hancock & Warm, 1989). With respect to the former, stress may be conceptualized as "cognitive patterning" that comprises the response to stress that varies across different sources of environmental demands (Hockey & Hamilton, 1983) or as a cognitive appraisal regarding the meaningfulness of the stressor and one's capacity to effectively respond to it (Lazarus & Folkman, 1984). Stress is thus a *relational construct* in that it arises from a transaction between the person and the demands of the environment (Lazarus, 1999; Matthews, 2001). From a transactional perspective, stress is defined as an appraisal by an individual that an event or stimulus is a threat to his/her physical or psychological well-being and that the demands posed by the environment exceed the individual's available resources to effectively cope and respond (Lazarus & Folkman, 1984; Lazarus, 1999; Matthews, 2001). Transactional theory can account for why stress responses vary widely across individuals and contexts. A given stimulus may induce a different stress response in two individuals because of differences in how they appraise the event (i.e., the *meaning* of the event for the well-being of one person may differ from that of another person). However, a particular individual may respond quite differently across different situations because different stimuli have distinct patterns of effect on cognition (Hockey & Hamilton, 1983).

META-THEORETICAL ISSUES

The Relational Approach: Implications for Stress as Outcome versus Cause

In conceptualizing and studying stress, it is important to specify whether one is investigating stress as a causal agent (e.g., how stress impairs performance or health) versus a consideration of stress as an outcome (e.g., the effect of task load on stress response). In essence, stress may be viewed as either a cause or an effect, depending on which portion of the transactional cycle one chooses to examine. From this perspective, cause versus effect is a misleading question because it inappropriately focuses attention on stress as a static psychological construct distinct from the context and frozen in time. A better question is how environmental demands affect an individual's response and how this transaction manifests in terms of cognitive state (Hockey, 1984, 1997, 2003) and adaptation to the environmental demands (Hancock & Warm, 1989).

Relation of the Stress Construct to Fatigue and Workload

Research on stress, fatigue, and workload comprises distinct but related literatures. There have been attempts at integration in which these phenomena are framed as interacting *biobehavioral states* (Gaillard, 2001) or as *operator functional states*

(Hockey, 2003), and stress, fatigue, and workload have been linked to common theoretical frameworks (e.g., Hancock et al., 2012; Hockey, 2012). However, they are distinct constructs. It is clear that workload can be stressful (Hancock & Warm, 1989; Hancock & Caird, 1993) and that compensating for fatigue can increase stress (Hancock & Verwey, 1997; Desmond & Hancock, 2001). However, the causal interrelationship among these constructs remains to be clearly defined. In many domains, including EMS, all three phenomena affect performance and well-being, and for these applications, the concept of operator functional state proposed by Hockey (2003) may be particularly useful. This concept integrates stress, fatigue, and workload in a common state construct defined in terms of an operator's adaptive capacity (see Hancock & Warm, 1989).

Cognitive–Energetic Perspective

The approach adopted here may be considered an "energetic approach" to human performance (Kahneman, 1973; Hancock & Warm, 1989; Hockey, 1997). In contrast to the unitary arousal theory (Hebb, 1955), the cognitive–energetic perspective views performance not as an outcome of a single arousal mechanism but rather as an outcome of cognitive capacities or resources allocated to tasks that individuals must perform (Kahneman, 1973; Norman & Bobrow, 1975; Wickens, 2002). These resources are energetic in that arousal influences the amount available at a given moment, but they are also structural in that they represent attentional capacity (Hancock & Warm, 1989; Hockey, 1997; for a discussion of energetic and structural metaphors for resources, see Hancock & Szalma, 2007; Szalma et al., 2012). The cognitive–energetic approach views stress as a multidimensional construct composed of affective, cognitive, and energetic components (Matthews et al., 2002).

THEORIES OF STRESS

There are three theories of stress that have been most influential in human factors research on performance in operational settings. These are the dynamic adaptability theory (Hancock & Warm, 1989), the compensatory control model (Hockey, 1997), and the cognitive appraisal theory (Lazarus & Folkman, 1984). The three perspectives are complementary rather than contradictory (Hancock & Szalma, 2007, 2008; Szalma et al., 2012). Theoretical integration is outside the scope of this chapter, but all three theories are compatible with the view that stress occurs when the resources demanded exceed those available for allocation to the task. These mechanisms operate at multiple levels within the organism, ranging from neurological to molar behavior (Matthews, 2001).

Appraisal (Transactional) Theory

One of the most well-known cognitive theories of stress is the transactional theory advocated by Lazarus (Lazarus & Folkman, 1984; Lazarus, 1999). It was conceived as a broad theory applicable to acute and chronic life stress, but Matthews (2001) proposed a transactional perspective that emphasizes the importance of cognitive mechanisms of appraisal and choice of coping strategy for understanding the performance effects of stress. The cognitive, affective, and energetic components of stress, as well as performance outcomes, result from cognitive appraisals and self-regulatory coping mechanisms (see Figure 5.1). These processes are determined jointly by environmental factors and the personality of the individual (Lazarus & Folkman, 1984; Matthews, 2008).

The outcomes of the evaluative processes are patterns of appraisal called "core relational themes" (Lazarus, 1991). For instance, the core relational theme for anxiety is existential threat. Thus, stress occurs when events are appraised as hindering or blocking attainment of their desired outcomes (goals). Three core relational themes have been found to be particularly relevant to responding to stress in a performance context, and they correspond to three dimensions of cognitive state that vary as a function of stress (Matthews et al., 1999, 2002, 2013). These are *task engagement*, which reflects the core relational theme of commitment to effort (toward task goals); *distress*, which reflects the theme of overload of processing capacity; and *worry*, which is related to the theme of self-evaluation (for a more detailed treatment, see Matthews et al., 2002). Several studies have established that manipulation of task demands is associated with predicted changes in task engagement, distress, and worry and that personality traits can predict cognitive states (Matthews et al., 1999, 2013; Szalma, 2009; Szalma & Taylor, 2011).

Dynamic Adaptability Theory

The dynamic adaptability theory (Hancock & Warm, 1989) asserts that contrary to the unitary arousal theory, in which there is a single point of optimum adaptation to environmental demand, most individuals are able to maintain stability in adaptation across a wide range of stressors. Further, this adaptation occurs as multiple levels (cf. Matthews, 2001), and stress can occur as a result of excessive demands (hyperstress) or an excessive absence of stimulation (hypostress; see Figure 5.2a). Increases in stress in either direction push the organism beyond the threshold of dynamic stability, at which point the organism experiences adaptive failure. However, there are multiple forms of adaptation, including affective ("comfort" in Figure 5.2a), behavioral ("psychological" in Figure 5.2a), and physiological. Failures of the different forms of adaptation occur progressively, such that comfort fails first (e.g., one can experience discomfort under stress but maintain high levels of performance), followed by performance and, finally, failure in physiological adaptation (e.g., loss of consciousness; Harris et al., 2005; Tripp et al., 2009).

Hancock and Warm (1989) also identified the task that a person performs as the most proximal source of stress, and they identified two component dimensions of information in the environment that comprise the demands placed on the individual: information rate and information structure (see Figure 5.2b). The former corresponds to the temporal aspects of a stressor (e.g., rate of events, time pressure), and the latter corresponds to how the information is organized within a given task and reflects primarily a spatial dimension of task demands. Both dimensions represent the information in the environment that individuals evaluate and respond to in order to adapt (or fail to adapt) to the circumstances that confront them.

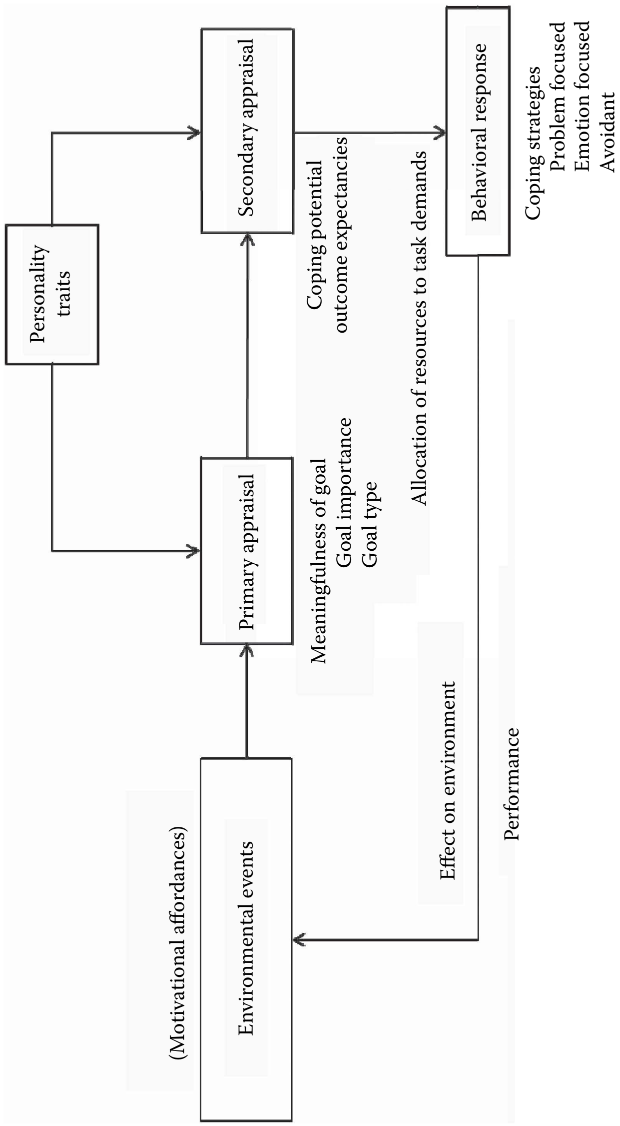

FIGURE 5.1 The transactional model of stress.

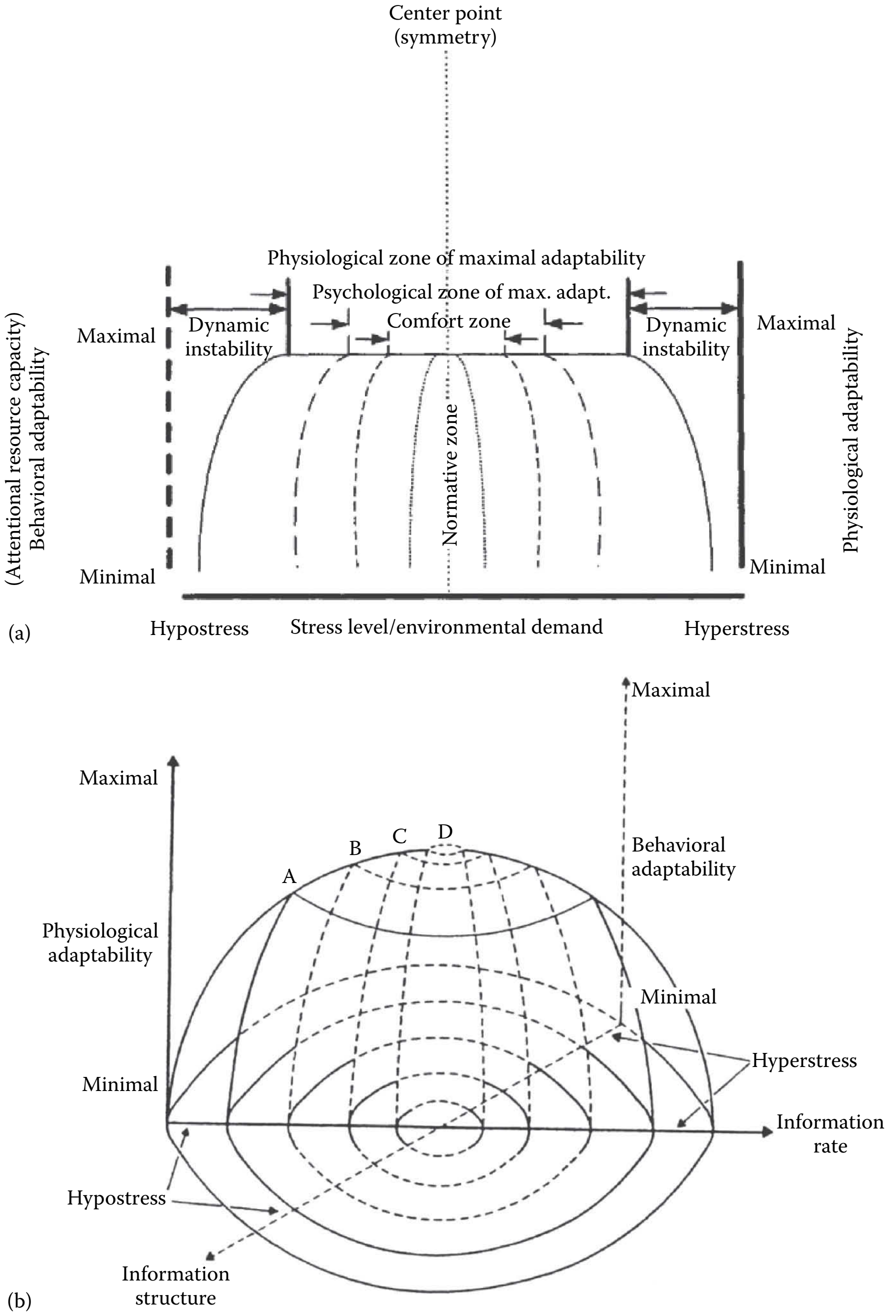

FIGURE 5.2 The dynamic adaptability model of stress (a) and a version of the model in which the stress continuum has been decomposed into its component information dimensions (b). (From Hancock, P.A., and Warm, J.A., *Human Factors*, 31, 519–537, 1989. With permission.)

Compensatory Control Model

The dynamic adaptability model accounts for changes in adaptation level as a function of stress imposed, and appraisal theories provide explanations for the role of cognitive mechanisms in stress response, but neither of these theories describes allocation of effort or the mechanisms by which individuals self-regulate behavior (although the latter is implied in both models; Lazarus & Folkman, 1984; Hancock & Warm, 1989). The compensatory control model (CCM; Hockey, 1997, 2003, 2012) was developed to account for the cognitive patterning (Hockey & Hamilton, 1983) of stress and the dependency of operator response on engagement in the task.

The CCM is based on three assumptions: behavior is goal directed, self-regulatory processes control goal states, and regulatory activity has energetic costs (i.e., consumes resources). According to this theory, performance is maintained via a negative feedback self-regulatory control mechanism in which environmental demands are evaluated via an appraisal mechanism, and when a discrepancy is detected, an effort monitor engages a higher-level regulatory loop that provides additional mental resources to accommodate the demand (see Figure 5.3). The lower loop shown in Figure 5.3 (loop A) controls behavior in a relatively automatic fashion and is engaged in contexts in which little effort or mental capacity is required (cf. Schneider & Shiffrin, 1977). However, when the demands are increased beyond the capacity of the lower loop and this increase is detected by the effort monitor, the individual may

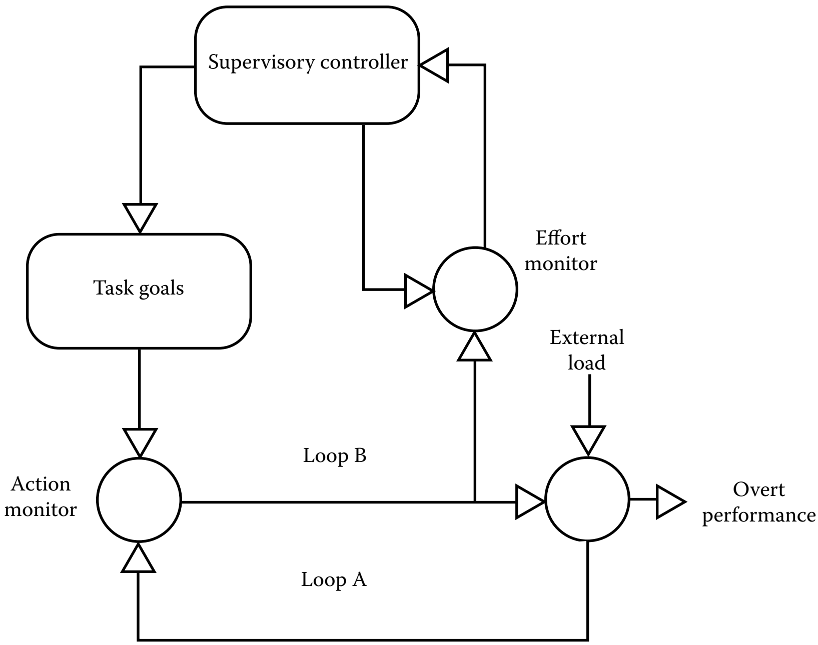

FIGURE 5.3 The CCM. (From Hockey, G.R.J., *Operator Functional State: The Assessment and Prediction of Human Performance Degradation in Complex Tasks*, IOS Press, Amsterdam, 2003. With permission.)

engage the upper loop (loop B) to allocate the necessary resources to maintain task performance. Increases beyond the capacity due to extreme demand or extended periods of work of this upper loop will eventually result in performance failures because the repetitive use of the regulatory process fatigues or strains the compensatory mechanism.

Hockey (1997, 2003) emphasized that the engagement of the upper loop requires expenditure of energy (compensatory effort) and therefore imposes a "hidden cost" to performance, which he referred to as a latent performance decrement. Whether such costs are incurred depends on the decision of an executive function (the supervisory controller in Figure 5.3), which, as seen in Figure 5.3, chooses between two alternatives of increasing effort or adjusting task goals. As Hockey (2003) himself noted, the importance of choice in this model differentiates it from traditional resource theory (Kahneman, 1973) because whether resources are allocated to the task depends on the strategy that the person chooses and is therefore not an automatic compensatory response. If the individual decides to allocate more effort to a task, then increases in demand or prolonged engagement of the compensatory mechanism places him/her in "strain mode," which increases the risk of performance failure. These hidden costs occur in terms of both cognitive states (e.g., distress, worry) and physiological arousal, which occurs as a result of regulatory control activity rather than as a result of changes in the task or other aspects of the environment (Hockey, 1986).

The supervisory system has two strategic responses from which to choose: increasing effort by allocation of more resources to the activity or changing the task goals. The latter modification can be in terms of the kind of goal (abandoning one activity in favor of another) or the magnitude of the goal (e.g., lowering the criterion for acceptable performance). Essentially, this process adjusts the difference between goal state and current state by allocating more effort or changing the goal, represented in Figure 5.3 as the two outputs from the supervisory executive. Effortful coping results in a strain mode of self-regulation, while the reduction of effort or performance goals is a "passive" mode of control (Hockey, 1997).

STRESS MITIGATION

Techniques for stress mitigation tend to fall into three general categories: (i) training on the task, on coping strategies, or on both; (ii) design (or redesign) of the task structure, the interface, or both; and (iii) selecting individuals who are resilient to stress. With respect to the latter approach, I have previously argued (Szalma, 2008, 2009) that measuring individual differences is useful for selection but that a potentially more powerful application of individual differences is to the design of tasks and interfaces as well as in training methods, both adaptive as well as general procedures. Hence, it is recommended here that training and design are the better approaches to mitigating negative stress effects in operational environments, as selection may not always be feasible and consideration of individual differences can improve the design of both technology and of training regimens for all workers in a given domain.

Training for stress may include training individuals to be more resilient by developing more effective task-coping strategies; training on the task so that fewer cognitive capacities are required and, therefore, performance is less vulnerable to the detrimental effects of stress (training to automaticity; Wickens et al., 2013); or training on the task under stressful conditions to "inoculate" the individual to performance-based stress effects (e.g., Varker & Devilly, 2012; for more general treatments outside the EMS domain, see Driskell et al., 2008; Johnston & Cannon-Bowers, 1996).

In EMS operational settings, there are multiple forms and sources of stress; the best approach is likely to be one that includes all three forms of training. Any training procedures for stress should include mastery of effective coping strategies, as maladaptive coping strategies (e.g., avoidant coping; Lazarus & Folkman, 1984; Matthews & Campbell, 1998) are associated with greater stress symptoms in EMS personnel (Holland, 2011). However, further research is needed to determine the best format for training. It is unlikely that traditional workshop-style training will be as effective as training procedures in which the individual has the opportunity to practice the task and coping strategies. However, extensive programmatic research to determine the relative efficacy of different forms of stress training (e.g., in randomized controlled trials) has yet to be done (although for an exception, see Tuckey & Scott, 2014).

Task structure and the interface can each be modified to aid performance in stressful work conditions by following one general but crucial guideline: simplify. This is a guiding principle for human factors in general—to create tasks and interfaces that are as simple as possible to use without sacrificing the necessary functionality. However, simplicity in cognitive demands is particularly important in stressful situations. Tasks that require resource-intensive information processing are the most vulnerable to stress effects (which is why training to automaticity when possible is a useful stress mitigation strategy). Hence, to reduce stress effects, designers should ensure that the tasks require minimal cognitive resources.

There are forms of task structure that may lend themselves to effective support of performance under stress. For instance, Hancock and Szalma (2003) described an approach to preserving performance in stressful environments by using relatively simple perceptual displays (e.g., object or configural displays; see also Szalma, 2011). In the EMS context, this means that displays should be designed so that the information that they present to the operator can be extracted quickly because the elements that convey the information are easily extracted via relatively low-level perceptual mechanisms (e.g., variations in shape, size, or color). In adaptive systems, it may be possible to modify displays for supporting different phases of operator functional state, although use of adaptive displays merits caution as it can potentially introduce system complexity that can undermine functionality.

CONSIDERING THE WHOLE PERSON: STRESS MITIGATION VIA MOTIVATION DESIGN

Task performance does not occur in a vacuum, and human operators are not "pure" information-processing devices without emotions or motives related to their activities. One approach to increasing stress resilience is to structure the tasks, the contexts, and the procedures to be *meaningful* to the person. How one responds to stress and even trauma depends, in part, on the meaning that one ascribes to the experience (Frankl, 1984). If the activity is evaluated as important relative to a person's self-related goals (i.e., goals that are highly valued and integrated with one's sense of self; Ryan & Deci, 2008), then the motivation to perform the activity is strengthened (Sheldon & Kasser, 1995; Deci & Ryan, 2000; Ryan & Deci, 2000, 2001). However, the meaningfulness of interaction with specific tasks involving use of technology, beyond immediate and proximal task goals, has been largely neglected in human factors research (for exceptions, see Hancock, 2009; Szalma, 2014). Szalma (2014) recently proposed a model and set of general guidelines for incorporating motivation theory into human factors design.

Self-Determination Theory

Self-determination theory (SD theory) distinguishes intrinsic motivation from multiple forms of extrinsic motivation (Deci & Ryan, 1985, 2000; Ryan & Deci, 2000, 2008). Intrinsic motivation occurs when the individual experiences inherent satisfaction from the behavior (Ryan & Deci, 2008). A person is "intrinsically motivated only for activities that hold intrinsic interest for them, activities that have the appeal of novelty, challenge, or aesthetic value" (Ryan & Deci, 2000, p. 71). Extrinsic motivation results from an external source, even in cases in which the external value has been internalized. There is strong evidence supporting a distinction between intrinsic and different forms of extrinsic motivation, and there are multiple factors that influence whether behavior is intrinsically or extrinsically motivated (e.g., see Deci et al., 1999).

SD theory assumes that motivation is energized by three innate psychological needs. These are the needs for autonomy (self-determination, an internal perceived locus of causality), competence, and relatedness. These needs and the proposed cognitive evaluation mechanisms of self-regulation are not unique to SD theory. However, the theory is unique in the integration of these constructs from diverse perspectives on motivation as well as in the distinction among qualitatively different forms of motivation. This latter characteristic differs from theories that propose a single self-regulatory (Carver & Scheier, 1998) or goal setting mechanism (Locke & Latham, 1990).

In brief summary, intrinsic motivation is supported by environments that afford autonomous behavior (i.e., choice; Dember & Earl, 1957) and promote development of competence (White, 1959)—and its subjective resultant, self-efficacy (Bandura, 1997)—and relatedness or a sense of meaningful connectedness with other individuals or agents in the environment. Conditions that interfere with or prevent need satisfaction undermine intrinsic motivation.

Forms of Extrinsic Motivation: The Importance of Autonomy

There are four forms of extrinsic motivation that differ in the level of autonomy experienced by the individual. These are illustrated in Figure 5.4. The lowest level of autonomy is "external regulation," in which behavior is directly regulated by externally determined response contingencies. The next level of extrinsic motivation is

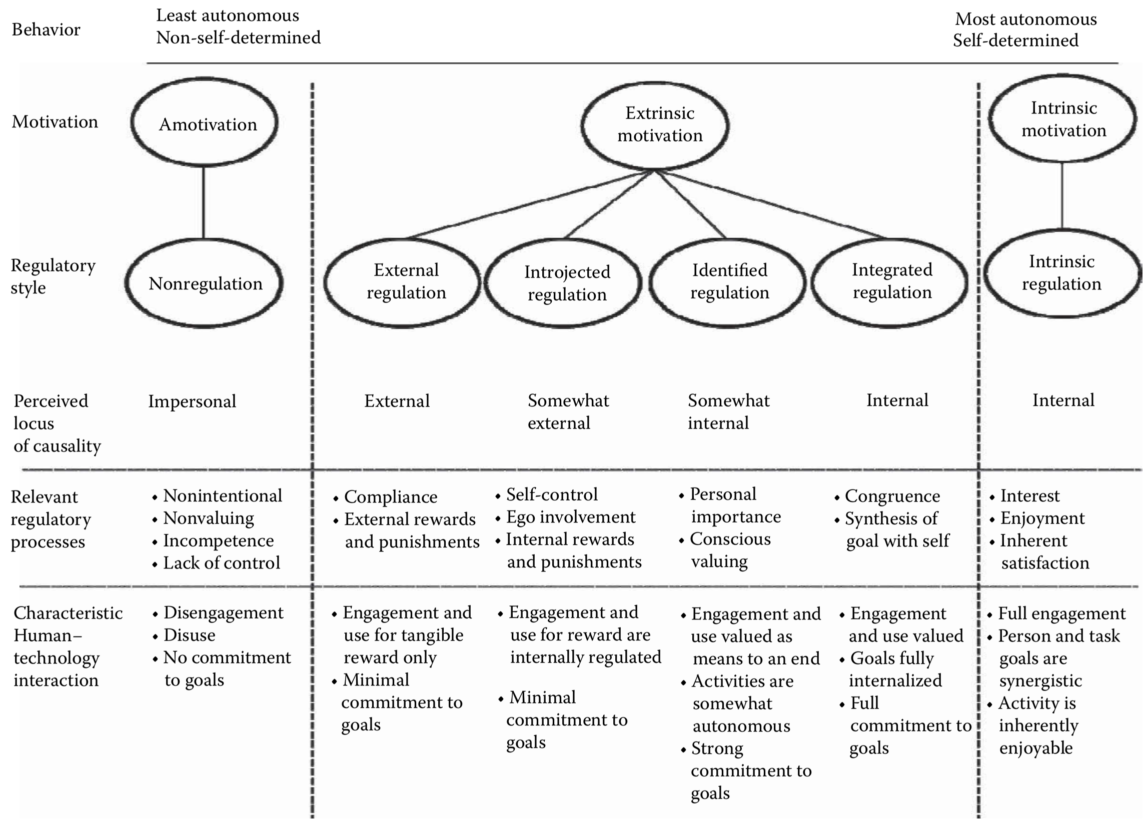

FIGURE 5.4 The forms of motivation and self-regulation in human–technology interaction. (From Szalma, J.L., *Human Factors*, 56, 1453–1471, 2014. With permission.)

introjected regulation, composed of external contingencies that the individual him/herself regulates. The goal is internalized only to the extent that the person self-regulates their response to the external contingencies. Identified regulation is characterized by external factors that have been internalized by the person and are not linked to specific contingencies. The individual understands the value of the activity for its own sake, as a means to an end, and values it, but the activity is a requirement imposed by an external source. Integrated regulation, the most autonomous form of extrinsic motivation, occurs when a goal is considered important because its value has been integrated (internalized) into the person's self-concept. Goals pursued as identified or integrated regulation are considered *self-concordant*, because the goal-directed activity is congruent with the values and goals that comprise part of the person's self-concept (Sheldon & Elliot, 1999). Integrated regulation is fully autonomous but differs from intrinsic motivation because it results from the utility of the activity for supporting attainment of personally important goals rather than the inherent interest in the activity itself.

Although intrinsic motivation may not be a realistic goal for EMS personnel, identified and integrated regulations are realistic and possible without the need to derive entirely new ways of organizing technological interfaces or the principles of design on which they are based. Creating a work environment, at both the immediate task level and the organizational level that facilitate identified or integrated regulation, will provide the mindfulness of work activity that can confer the resilience to stress individuals in this profession need. The crucial ingredient is provision of real autonomy to workers.

IMPROVING STRESS RESILIENCE THROUGH MOTIVATIONAL DESIGN

One way to increase stress resilience is to create contexts that support self-concordant integrated self-regulation. Szalma (2014) has outlined a framework for applying motivation theory to human factors design (see Figure 5.5), and these guidelines can easily be applied to the design for stressful jobs. In fact, there are particular examples in which EMS stress mitigations have already been developed that incorporate the motivational component (perhaps inadvertently) of performance and stress. Halpern et al. (2009) investigated themes associated with the stress occurring after a critical incident, and they reported that emotional support by one's supervisor and provision of a "timeout" period allow the emotional arousal that occurred immediately after the incident to dissipate.

The two interventions recommended by Halpern et al. (2009), emotional support from the supervisor and a timeout period soon after the stressful event, are likely effective because they support the autonomy and relatedness needs of the individual. In fact, the emotional support recommended by Halpern et al. (2009, p. 146) "consists of: acknowledgement of the incident as critical, valuing the work done by the emergency medical technician (EMT), concern about the well-being of the EMT, willingness to listen and to offer material help." All of these techniques are recommended ways to promote a work environment that supports autonomy and relatedness (Gagne et al., 1997; Gagne & Deci, 2005; Stone et al., 2009).

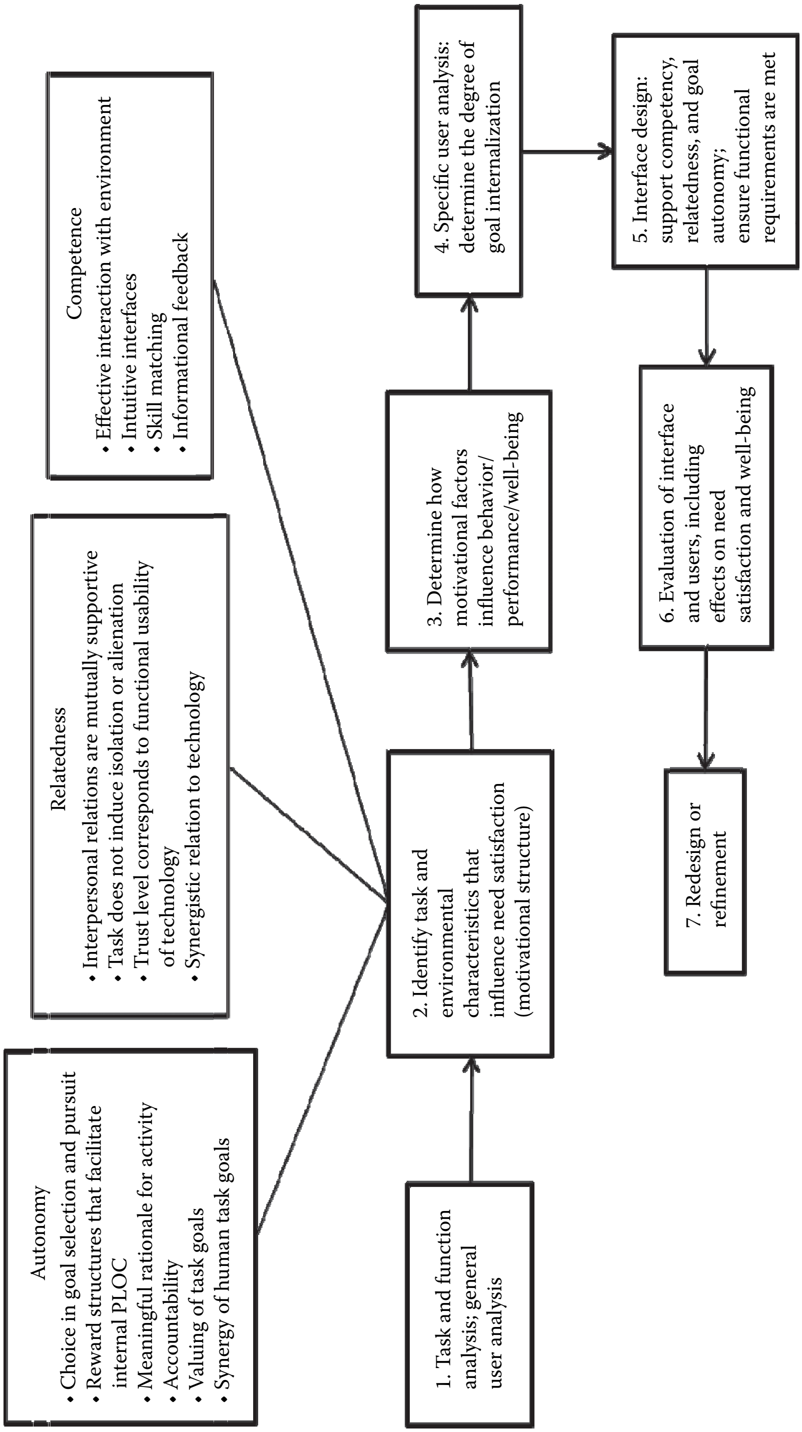

FIGURE 5.5 Guidelines for motivational design in human factors and ergonomics. PLOC, perceived locus of causality. (From Szalma, J.L., *Human Factors*, 56, 1453–1471, 2014. With permission.)

These approaches can reduce occupational exhaustion and enhance commitment (Fernet et al., 2012), possible by facilitating stronger personal resources to respond to job demands (Van den Broeck et al., 2011). Facilitating need satisfaction has been shown to reduce the effects of poor job resources (e.g., limited physical and organizational resources for accomplishing job-related tasks) on exhaustion (Van den Broeck et al., 2008) and to enhance psychological health (Boudrias et al., 2011). Implementing these techniques in EMS organizations should have beneficial effects in terms of performance and stress mitigation, as well as in the engagement and commitment of EMS personnel.

GAPS IN UNDERSTANDING

There are both theoretical and practical gaps in understanding that should be addressed to further advance the field of stress and performance. The central theoretical gap is the refinements of the stress construct itself. Stress is a functional state with biological, cognitive, and emotional components (Gaillard, 2001). Research efforts should therefore be directed toward a further exploration of the intersections of these elements and of how these interactions affect manifestations of stress response. Accomplishing this will require refinement of currently vague constructs such as cognitive resources, as well as more precise models of cognitive appraisal and of how individuals evaluate goal progress.

A second theoretical gap is in our collective understanding of how individual differences in personality and in cognitive abilities (or skills) affect the experience and performance under stress. Personality has been examined extensively in stress and health research (e.g., for a general review, see Matthews et al., 2009), but its application to cognitive performance under stress, particularly in operational settings, has been somewhat limited. This is likely due to long-standing divisions between disciplines of psychology (Cronbach, 1957, 1975), although there have been efforts to include individual differences in stress and performance research (Hockey, 1986; Matthews et al., 2000, 2009; Szalma, 2008). Further, guidelines for incorporating individual differences into human factors design processes have been proposed (Szalma, 2009), and these can be applied to the design of tasks, interfaces, and training procedures described earlier in this chapter. Motivational design has the potential to ameliorate stress by providing experiences of autonomy, competence, and relatedness that provide meaning to a task (Sheldon et al., 2004) and energize behavior (Nix et al., 1999; Moller et al., 2006; Ryan & Deci, 2008). However, empirical research on stress and performance has yet to fully exploit these methods for the design of real-world operational environments.

CONCLUSIONS

Stress is ubiquitous and it is likely to continue to pose constraints on effective performance in operational settings. Given the literal life-and-death situations faced by EMS personnel, there will always be some degree of stress for medical service providers. Hence, mitigation strategies that involve removal of the source of the stress (e.g., by eliminating noise or controlling the ambient temperature) are unlikely to be effective in the EMS context because stress is an inherent component of the operational environment.

The best approach to confronting stress is therefore to develop ways to reduce its effects on performance and well-being. The best approaches are training and the design of the environment, specifically the task, the interface, and the motivational structures. Stress for EMS personnel will never be completely eliminated, but application of stress theory and research and the mitigation strategies derived from them offer effective ways to manage the stress associated with work in emergency medicine.

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