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The Effects of Acute Stress on Performance: Implications for Health Professions Education

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Abstract

Purpose
This paper is a review of representative research on the impact of acute stressors on the clinical performance of individuals and teams.

Method
The Sciences Citation Index, Medline, and Psychinfo were used to search for articles up to and including 2008. The search terms were stress/tension/arousal/anxiety/cortisol/threat, cognition/skills/memory/attention/problem solving/decision making/performance, stress reduction/stress exposure/stress management/stress inoculation, and health professionals/medicine/medical students/residents/physicians/teams. The search was limited to papers in English from all developed countries. Secondary references were selected from primary papers.

Results
Elevated stress levels can impede performance on tasks that require divided attention, working memory, retrieval of information from memory, and decision making. These effects appear to be determined by the individual's appraisal of the demands and resources of a situation, the relationship between the stressor and the task, and factors such as coping styles, locus of control, and social supports.

Conclusions
Given the potential negative impact of stress on performance, and the individualistic way in which people respond, medical educators might want to consider avenues for training learners in stress management. More research is needed to fully understand the contributions of personal factors such as coping style and locus of control, as well as the relationship of perceptions of stress to issues such as fatigue.

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Training to become a physician and the practice of medicine are activities that contain a significant amount of stress for individuals. Common sources of stress include treating critically ill and rapidly deteriorating patients, performing high-intensity procedures, functioning while sleep deprived, inadequate personal time, disruptions in social support, licensing examinations, and conflicts between clinical and educational responsibilities.[1–7] These stressors have significant effects on individuals. Most,[1,5,7–10] but not all,[11–12] researchers observe that approximately 25% to 35% of medical trainees report symptoms of anxiety and/or depression in response to the stressors they encounter.

Despite the documented link between job stress and mental health,[13] there is little research on the impact of stress on clinical performance.[14] It is important to understand how stress affects clinicians' or trainees' abilities to process clinical information, remember this information, make decisions, function as teams, and carry out necessary clinical procedures. If stress, in addition to its impact on well-being, impairs learning and medical decision making, patient care and safety could be jeopardized. Understanding the extent to which stress affects clinical performance will allow us to effectively target technological and educational interventions where they are most likely to be of benefit. The aim of this paper is to review representative research focused on both the positive and negative effects of acute stressors on the cognitive abilities (i.e., memory, attention, reasoning, problem solving) of individuals and teams. The literature in several domains of research will be examined for the purpose of generating a coherent and comprehensive representation of the effects of stress in clinical practice and of mechanisms for addressing these effects. The explicit focus is on what happens during acutely stressful events, because this is an area of inquiry that has received relatively little systematic inquiry in health professions education. Links to the broader literature regarding topics such as sleep deprivation and the potential effects on suicide, divorce, and other health indicators are beyond the scope of this paper. The effects of stress on procedural and motor skills are also beyond the scope of this paper.

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Method

Although relatively little research has been conducted on this topic in the domain of medical education, there is a substantial body of literature from the psychological domain addressing the effects of stress on cognitive abilities and performance. The purpose of this review is to summarize the body of literature on the effects of acute stressors, to discuss the implications of these findings to health professions education and practice, and to discuss some promising methods aimed at reducing the negative effects of acute stressors on performance.

The Sciences Citation Index, Expanded (containing the Sciences Citation Index, the Social Sciences Citation Index, and the Arts and Humanities Citation Index), Medline, and Psychinfo were used to search for articles up to and including 2008. The following searches were conducted: (stress OR tension OR arousal OR anxiety OR cortisol OR threat) AND (cognition OR skills OR memory OR

attention OR problem solving OR decision making OR team performance OR performance), (stress reduction OR stress exposure OR stress management OR stress inoculation), and (stress) AND (health professionals OR medicine OR medical students OR residents OR physicians OR teams). The search was limited to papers in English from all developed countries. Secondary references were selected from primary papers. The use of the search terms revealed more than 1,000 peer-reviewed publications, including the bulk of the literature which addresses chronic stress and anxiety, as well as clinical levels of anxiety. A review of the abstract of each article to identify those that discussed acute stressors led to the selection of the 99 publications cited in this review.

What is stress?

The term "stress" was coined in the 1930s by the endocrinologist Hans Selye.[15] After exposing animals to various noxious stimuli, he found that they all showed a similar reaction that he labeled the General Adaptation Syndrome (GAS). The GAS contains three phases: an *alarm phase* in which an organism identifies a stressor or a threat and the body mounts an alarm response, a *resistance phase* in which the body attempts to adapt and cope with the stressor, and an *exhaustion phase* in which the resources are eventually depleted in the face of sustained stress and the body is unable to maintain normal function. The exhaustion phase can lead to long-term damage to the adrenal glands and the immune system, leading to depression, cardiovascular problems, and other mental issues.[16,17] While the latter two stages of the GAS have been instrumental in understanding the effects of chronic stress, the first stage (the alarm phase) is most pertinent to the study of performance under acute stressors and will be the main focus of this review.

The initial stress response is theorized to result from the interaction of the demands placed by an individual's environment and that person's resources to meet the demands. It is heavily influenced by a person's assessment of the situation.[18,19] When individuals perceive a real or anticipated challenge to their primary goals (i.e., passing a licensing exam, keeping a patient stable during surgery), they appraise the situation in a two-stage process. In a first stage of appraisal, they assess the demands required of the situation to reach or maintain the desirable goal. In a second stage of appraisal, they assess the resources—personal and environmental—available to meet the perceived demands of the situation. When the resources are assessed as being sufficient to meet the demands, the situation is assessed as a *challenge* and a positive psychological state of "eustress" ensues.[19] When the demands are assessed as outweighing the resources of the individual, the situation is assessed as a *threat*.[19] A negative psychological response of "distress" ensues, including a variety of affective states (the most common being anxiety).

After either a challenge or threat appraisal, the sympathetic nervous system (SNS) will be activated if an active response is required. This results in the very rapid increase, over a period of seconds, of heart and respiration rates.[20] In addition to the SNS response, a threat appraisal leads to the activation of the hypothalamic–pituitary–adrenal (HPA) axis.[21] The activation of the HPA axis results in the increased release of the hormone cortisol in the blood which is then diffused to the saliva over a period of minutes. This increase in cortisol levels influences areas of the brain that are heavily involved in cognitive processes: the amygdala, hippocampus, and prefrontal cortex.[21,22]

Thus, an individual's response (subjective and physiological) to demands that threaten an important goal is highly dependent on that individual's perception of the demands and of his or her resources available to meet those demands. Any factor that increases the perceived demands of a task or decreases the perceived resources to meet those demands increases the likelihood of a distress response. Socioevaluative stressors (where others could negatively judge performance) and uncontrollable stressors are the most likely to provoke a distress response.[21] In the context of this paper, the terms "stress" and "stress response" will be used when referring to the distress response that ensues once a situation is assessed as a threat to maintaining or achieving a primary goal.

Results

Stress and performance

To date, there has been relatively little research looking at the specific effects of stress on the performance of health professionals. Of the research that does exist, the findings are ambiguous. Some studies have shown impaired performance under acutely stressful conditions,[23,24] while others have shown improved performance.[25] The paucity of research and seemingly conflicting results have allowed the development of somewhat naïve perceptions by health professionals and educators regarding the effects of stress on performance. Beliefs that stress can enhance learning ("you learn better under the gun") coexist closely with beliefs that learning is optimized in conditions that are free of anxiety and stress. As a community, the risk we face by not fully understanding the effect of stress is that we could fail to adequately prepare individuals to function in emergency or crisis situations or, even worse, impair learning and acquisition of these skills.

The effects of stress on performance have been investigated quite extensively in domains such as psychology, high-risk industries (nuclear power plants, aviation, law enforcement), and psychoneuroendocrinology. In all of these domains, research into the effect of stress presents many challenges. Most important, it is difficult to predict when acutely stressful events (crises, emergencies) will occur in real life, and it is unethical to manipulate stressors during real-world events. As such, researchers have developed various approaches to investigate the effects of stress, from retrospective reviews of critical nuclear or aviation incidents, to high-fidelity simulations of military, nuclear, and aviation operations, to interventional studies in which the physiological processes of stress responses (elevated heart rate and cortisol levels) are recreated with the administration of pharmacological agents. Although each particular method has recognized limitations in the conclusions that can be drawn from its results, these various methods converge to allow us to draw some conclusions regarding the effects of stress on attention, memory, decision making, and, to some extent, group performance.

Stress and attention. In their everyday activities, individuals are bombarded with all sorts of perceptual information. However, our ability to process this information is limited. Under stressful conditions, the cognitive system becomes overloaded, decreasing a person's attentional resources.[26]

The effects of this stress-related reduction in attentional resources on selective attention remain unclear. *Selective attention* is the process that allows us to focus on those stimuli that are relevant to us, preventing the cognitive processes from becoming overloaded with information. It is the filter that determines what information is processed and what is ignored. Some researchers argue that selective attention is facilitated under stressful conditions and that the limited resources are allocated to information that is relevant to the task being completed rather than to information that is irrelevant. As stress increases and attention becomes more selective, there is a growing exclusion of information that is irrelevant to the task at hand, a process called cue utilization reduction by.[26] As such, stress will be beneficial when a task requires the exclusive focusing on target information. Alternatively, there is also some evidence that the reduction of attentional resources under stress may result in a decreased ability to filter out irrelevant information from relevant information.[27] Hence, stress can also lead to increased distractibility of the individual.[28]

An explanation of the conflicting findings regarding the effects of stress on selective attention may lie in the relationship between a stressor and the task being performed. When feeling anxious, people's attention is biased towards threat-related information.[29] Selective attention will be focused on those aspects of a stressful situation that induce the stress response. As such, if the task being performed is integrally related to the source of the stress (resuscitating a patient), then selective attention should be narrowed towards the task itself. However, if the source of stress is peripheral to the task being performed (i.e., loud noises, disruptive team members), then attention will be focused on the source of the stress, to the increasing exclusion of information related to the task itself. As such, the restriction in selective attention may be disruptive to performance when the stress results from factors peripheral to the task and may facilitate performance when the task being performed is the source of the stress response.

Although there are conflicting findings regarding the effects of stress on selective attention, there is consistent evidence that *divided attention* tasks, those that require the integration of information from several sources, are vulnerable to the effects of stress and elevated cortisol levels.[26,30,31] For the emergency medicine trainee who is leading a cardiac arrest team, and who must process information from multiple sources, performance is likely to be impaired under stress. In these conditions, in which there are multiple targets, performance will be impaired because one target will be selectively attended to, to the exclusion of other relevant targets. Tunnel vision (extremely narrow perspective) and premature closure (tendency to stop considering other possible diagnoses after a diagnosis is reached) are more likely to occur.[32]

Stress and memory. Memory—the ability to store, retain, and subsequently retrieve information—is critical to every aspect of medical training and clinical practice. There is a general belief, based on subjective experience, that stress influences memory. Many clinicians anecdotally report that some experiences during their training or clinical practice seem as if they will be remembered for a lifetime, whereas other events seem to have been forgotten (or never encoded) because of the stress surrounding the event. A brief survey of the literature can also be confusing, with some studies showing that stress impairs memory[33,34] and others showing that stress enhances memory.[35,36] However, a close review of the literature reveals that the effects of stress depend on the memory phase that is activated during stressful situations.[22] Stress responses and increases in cortisol levels differentially influence three components of memory: working memory, memory consolidation, and the retrieval of information from memory.

Working memory. Working memory consists of the capacity to store and manipulate information for brief periods of time.[37] This is the process that allows the team leader in a cardiac arrest to simultaneously keep track of information gathered from multiple sources (clinical monitors, other team members), to keep previously learned information in mind (patient drug allergies), and to manipulate this information to reach clinical decisions. Elevated stress levels and cortisol levels appear to impair working memory.[37,38] Elzinga and Roelofs[39] observed that individuals who exhibited a threat response (cortisol and SNS responses) to a public speaking task were impaired on a task of working memory. In contrast, individuals who exhibited a challenge response (SNS arousal but not cortisol elevation) were not impaired on the working memory tasks. Similarly, Beilock and Carr[40] have observed that under pressure, individuals demonstrate performance decrements in solving a mathematical problem: a task that is thought to rely heavily on working memory. Working memory impairments are especially likely when the task load is high[22,37] and when performance is assessed during the stressful event itself.[39]

Memory consolidation. Memory consolidation is the process by which new and fragile memories are rendered into more stable and permanent memories.[41] Elevated stress responses, especially if they lead to increased cortisol levels, have been associated with the enhancement of memory consolidation.[22,35,42] Abercrombie and colleagues[43] asked participants to recall words they had learned two days earlier, immediately after being administered exogenous cortisol. The participants who had been administered moderate doses of cortisol (levels that mimic those observed during moderate stressors such as final examinations) performed better on a test of word recognition. The effect is especially strong for materials that are arousing or emotionally laden rather than neutral information.[22,36,44] In addition, the facilitation of memory consolidation processes only occurs at moderate stress levels; extremely high levels of HPA axis activation will impair memory consolidation.[43,45]

Therefore, the general belief that individuals learn better from stressful events is supported by the research, but with an important caveat. Information from a to-be-remembered event will be retained quite well if it is that event that causes the stress response in the individual. If the stress is caused by something that is peripheral to the to-be-

remembered information, the consolidation of that information will not be enhanced.[46] For example, a surgery resident who feels stressed during surgery because of an intimidating or abusive staff surgeon may develop a strong memory of the actions of the staff surgeon, but the resident's memory of the patient and of the surgery itself will likely not be enhanced. Similarly, a trainee who takes part in simulation sessions in which the primary source of stress is a socioevaluative one (being observed and assessed by a faculty member or fear of "losing face" in front of peers) will remember those aspects of the simulation session. However, the trainee's memory of the simulated scenario and associated learning points will not be enhanced. For trainees to have enhanced consolidation of the central details of a clinical case and, as a result, better learning, the case itself needs to be the source of the stress response.

Memory retrieval. In contrast to the facilitating effects on memory consolidation, stress leads to impairments in the retrieval of memories. In laboratory studies, elevated cortisol responses to psychosocial stressors (i.e., public speaking) led to impairments on tasks that required participants to remember previously learned information[47–49] and to remember prior autobiographical events.[50] As with working memory, it seems that the impairment in memory retrieval occurs when individuals have a threat response to stressors (and the accompanying cortisol response), with no impairments occurring in individuals who have a challenge response to a stressor. In a study by Buchanan and colleagues,[33] participants learned a list of words. One hour after learning the list of words, the participants were exposed to a stressor (immersion of hand in cold water) and then were immediately asked to recall the previously learned list of words. The participants who exhibited a threat response to the stressor (elevated cortisol responses and elevated SNS arousal) performed worse on the delayed recall test of the words. In comparison, those participants who exhibited a challenge response (SNS arousal without corresponding increase in cortisol levels) performed as well as participants in a control group. At lower levels of subjective stress, tasks that are dependent on the retrieval of information from memory are either unaffected or enhanced.[47,51] This effect seems to be limited to the free recall of information (when no cues are given to assist in the retrieval of information) and does not seem to impair recognition memory (remembering previously presented information when it is offered again).[33,34]

Consistent with these laboratory-based findings, LeBlanc and colleagues[24] have observed that skilled paramedics demonstrate significant impairments in the ability to solve drug calculation problems (a task that depends both on the retrieval of mathematical formulas from memory and in the storage and manipulation of information in working memory) immediately after working through highly stressful simulated scenarios. Thus, although a stressful learning episode may consolidate well into memory, the retrieval of previously learned material is less efficient under high levels of acute stress.

Stress and decision making. When stressed or anxious, individuals demonstrate an increased use of cognitive heuristics[52] and of decision-making strategies that are considered suboptimal. Vigilant decision making, considered optimal by many, consists of a systematic and organized information search, a thorough consideration of all available alternatives, the devotion of sufficient time to evaluate each alternative and the review of data before making a decision. In contrast, hypervigilant decision making is considered an impulsive and disorganized pattern of decision making. It consists of a nonsystematic or selective search for information, the consideration of only a limited set of alternatives, the rapid evaluation of the data, and the selection of a solution without reappraisal. The use of hypervigilant decision making when stressed has been associated with poor performance on laboratory-based tasks.[32,53]

However, hypervigilant decision-making strategies may represent adaptive responses to naturalistic task demands.[54] In naturalistic tasks, decisions need to be made under time pressure, the data are ambiguous and/or conflicting, and decision makers are likely familiar with the tasks. In such conditions, it is argued that decision makers can use their experience to identify meaningful data and to generate reasonable options.[55] In one of the few studies looking at decision making on naturalistic tasks under stress, researchers had participants identify unknown contacts that appeared on naval radar screens. These participants were familiar with the task. The results demonstrated that experienced participants who used hypervigilant decision-making strategies made a greater number of accurate identifications than those who used vigilant decision-making strategies.[54] More research is required to compare vigilant and hypervigilant decision making in novices exposed to stressful situations.

Stress and group performance. The complex and dynamic nature of the medical environment often requires teamwork. In crisis or emergency situations, individuals are required to work together in a coordinated fashion to make decisions about patient care.[56] Surprisingly, relatively little is known regarding the effects of stress on team work, group decision making, or performance. Much of the research on team performance under stress is based on retrospective reviews of aviation incidents or on observations of team work solely during crises or acute events.

The specific effects of stress on teams have been investigated with respect to two aspects of performance: team perspective and centrality of authority. Two groups of researchers have observed that increased stress leads to a loss of team perspective and decreased team performance on military decision-making tasks.[56,57] This decrease in team perspective is thought to result from the attentional narrowing that occurs in individuals under stress. Although these two studies provide some insights into the effects of stress and team performance, these findings have not been confirmed or replicated with studies looking at different tasks, group composition, or stressors. As for the effects of stress on the centrality of authority, the results are conflicting. Some researchers have observed a centralization of authority under stress, where the control and decision making become concentrated in the high levels of hierarchy.[58] In this case, team leaders were less receptive to input from other members of the team. In contrast, other researchers have observed team members becoming more receptive to information provided by other team members. During controlled laboratory decision-making

tasks, Driskell and Salas[59] observed that their participants were more receptive to input from teammates when making decisions in stressful conditions compared with low-stress conditions.

The large part of research looking at stress and team performance has been aimed towards understanding what characteristics of the team lead to optimal performance during high-demand situations.[60] A number of characteristics of effective team performance in stressful events have been identified, such as the ability to adapt to changing situations, effective communication, and effective resource allocation, as well as the presence of situation awareness and clear leadership. These characteristics seem to depend on the presence of implicit coordination.[60–63] Implicit coordination occurs when teams are able to predict the needs of the task at hand and anticipate the actions of other team members in order to adjust their behavior accordingly. This implicit coordination depends on a shared mental model, a common understanding of the situation and tasks at hand.[60] These mental models, when accurate, allow people to appropriately understand phenomena, draw inferences, make predictions, and decide what actions to take.[60,64] Shared mental models are essential to implicit coordination because they allow members of a team to generate predictions about tasks and team demands in the absence of communication between team members.[60]

Although this body of research describes the underlying processes of effective teams, it does not shed light into such things as the factors that enhance or impair the development of shared mental models or of the forces that influence or shape a team's coordination during high-acuity events.[65] As such, substantially more research is required to understand how stress affects team interactions and how team dynamics adapt to stressful events, as well as to identify the factors of the environment that erode team coordination.

Factors that affect stress response and performance

While the review of the literature above presents some general trends and patterns regarding the effects of stress on performance, researchers have observed significant individual differences in stress responses and performance. The most important moderators of stress responses and performance under stress are reviewed in this section.

Coping styles. A potentially important mediating factor in the appraisal of a situation as a challenge or a threat is an individual's coping style: the thoughts and behaviors used to manage both the internal and external demands of situations that are appraised as stressful.[66,67] Although there is some debate regarding the classification of coping strategies, there are three main categories of coping styles.[66,68] *Problem-focused coping* consists of addressing the problem causing the distress (i.e., having a plan of action, concentrating on the next step). *Emotion-focused coping* is aimed at reducing or managing the emotional distress that is associated with the situation (i.e., seeking emotional support, focusing on and venting of emotions). *Avoidance coping* is aimed at seeking to avoid or distract oneself from the situation (i.e., seeking out social diversion, engaging in distracting tasks). Problem-focused coping styles seem to be more effective in controllable situations in which individuals can manipulate the stressors,[69] and emotion-focused coping styles seem to be effective when dealing with stressors that are of brief duration and that cannot be controlled.[70–72] Avoidance coping styles, although associated with decreased subjective stress levels, have been associated with increased cortisol responses.[69] As such, they may be detrimental to performance under stressful circumstances.

Control. A second potentially important mediating factor is an individual's locus of control: the extent to which that individual perceives that he or she has control over a given situation. Individuals with an internal locus of control are those individuals with the perceived feeling of being able to control events in their lives. These individuals are likely to develop a positive outcome expectancy and, consequently, lessened stress responses and performance impairments in acutely stressful situations.[73] Individuals who, in the face of crisis, manage to retain a belief that they can control outcomes have been found to manage the experience far more effectively than individuals who believe they are controlled by external forces.[74,75] For example, higher levels of external control are associated with depression in paramedics.[76] Ambulance personnel reveal significantly more externality, thus less perceived control over what happens in their lives, which may make them more predisposed to the effects of stress.[77]

Social support. There is a substantial body of literature showing that individuals who have access to psychological support in demanding situations such as stressful employment or facing chronic stressors seem to be in better health compared with individuals without significant support. There is correlational evidence for beneficial effects of social support on endocrine and immune system parameters during stressful periods of life.[78] During acute stressors, the presence of social support is associated with decreased cortisol responses,[78] cardiovascular responses,[79] and subjective stress responses.[80]

Discussion

Although this critical review brings to light the fact that substantially more research needs to be conducted to gain a deeper understanding of stress responses and their impact on the performance of individuals and teams, some general patterns are emerging from the literature. First, stress is highly subjective. What is distress for one is eustress for another and a nonevent for a third. Second, it seems that the relationship between a stressor and a task is important in determining whether performance will be enhanced or impaired. When a stressor is contingent to the task being performed, a person's cognitive resources will be focused on that task, and certain aspects of performance may be facilitated. In contrast, stressors that are peripheral to a task seem to draw cognitive resources away from the task being performed, and performance is more likely to be impaired. These have important implications for health professions education and for how we prepare trainees to perform tasks under stressful conditions.

First, educators wishing to design stressful situations in the hopes of enhancing memory consolidation need to ensure that the source of the stress is intrinsically linked to the information that is to be learned. If the source of stress is peripheral to the task (i.e., having to perform in front of a group, or with

disruptive teammates, loud noises, or intimidating or challenging staff), then learning will not be enhanced.

The second important implication of these findings is that training for high-acuity events needs to go beyond training that is oriented solely towards the acquisition of skills and knowledge. Such training will be insufficient to prepare trainees to perform optimally under high-stress situations. In addition to this skills-based and knowledge-based training, training programs should supplement these with interventions aimed at developing the trainees' ability to cope with and withstand important stressors. Promising methods of training for stressful events are discussed in the following section.

Finally, the findings in this review bring to light the fact that more research is needed to gain a deeper understanding of the effects of stress, particularly in terms of attentional processes, decision making, and group performance. Furthermore, research looking at reactions to stress requires careful measurements to determine the level of stress, in particular distress, that is present in each individual participant. Mere immersion in a situation is insufficient because some are not stressed by that situation. Further, surface behavioral characteristics are insufficient; autonomic reactivity in the absence of cortisol elevations would imply eustress, not distress, and seems to have a decidedly different impact on the individual's performance.

Training for performance during stressful events

A number of approaches have been developed in an attempt to optimize performance during stressful events. These approaches can be categorized as either skills-based training or as stress management interventions. In skills-based training, the emphasis is on providing individuals or teams with the specific skills required during a crisis. In stress management interventions, the emphasis is placed on modifying the individual's appraisal of a potentially stressful situation. Promising examples of each approach are described in this section.

Skills-based training

Overlearning. Overlearning training consists of requiring trainees to keep practicing newly acquired skills after the skill has been acquired to a level of proficiency.[81] Overlearning can be effective in preparing trainees for performance under stressful conditions because of several factors.[72] First, complex tasks are more likely to be impaired under stressful conditions than simple tasks.[22,34] Overlearning can contribute to the simplification of complex task and can thus make them less vulnerable to stress.[72] Second, overlearning can lead to the automatization of skills so that they can be performed with little demand on cognitive processes.[82] This frees up cognitive resources that can then be applied to coping with the stress response or with other aspects of performance. Finally, when tasks are overlearned and well drilled into trainees' repertoire, this can increase their sense of control in performing the task.[72,82]

Although overlearning has the potential to be an effective method of preparing trainees for performance under acutely stressful conditions, its application can have significant drawbacks if it is not carefully designed and executed. One of the more important drawbacks is that overlearning can limit the individual's ability to demonstrate flexibility in his or her response and to adapt to changing conditions.[72,82]

Team training. Recognizing that sound medical and technical abilities, although necessary, are not sufficient to ensure competent team performance in crises, many educators have developed team training interventions.[83–86] The overall goal of team training is to foster the development of accurate shared mental models of patient care in high-stress situations.[82,87] Several models of team training have been developed and applied in the aviation and military environments, such as cross-training, perceptual contrast training, team coordination training, team self-correction training, and guided error training.[87] The model most widely applied in health professions is team coordination training, such as crisis resource management (CRM) training and medical emergency team (MET) training.[83,88] Originating in the field of aviation, CRM training recognizes that individual and team performance can be significantly degraded in crisis situations. Although approaches vary, they are typically tailored to anesthesia crises or cardiac arrests, and they generally center on the principles of situation awareness, establishment of leadership, clarity of roles, and personnel and resource management.[86] Similarly, MET training focuses on improving the organization, efficiency, and reliability of crises team responses by emphasizing the reinforcement of organizational aspects of team performance, such as assuming designated roles independently, completing tasks or goals assigned to each role, and directed communication.[83] In the majority of cases, this form of training consists of didactic lectures, followed by hands-on practice at resolving medical crises with feedback. Although the bulk of team training is conducted with high-fidelity computerized mannequins placed in realistic clinical scenarios, some groups use vignettes, role modeling of ideal behaviors by video, and role playing.[88] There is accumulating evidence indicating that this type of training improves team performance in simulated crises,[89] and there is some preliminary research indicating that team training can improve team performance at the bedside.[88]

Stress management interventions

Preparatory information. Based on the findings from medical studies that preparatory information can lessen negative reactions in patients about to undergo stressful clinical procedures, there is growing interest in the use of preparatory information for reducing stress reactions and enhancing performance in nonclinical settings.[90] Preparatory information is hypothesized to be effective by rendering the stressor and the task less novel and more familiar, and by enhancing the sense of behavioral or cognitive control over an aversive event.[72,90] The effectiveness of preparatory information lies not solely on a detailed description of an upcoming stressful event but also in providing information about prescriptive ways in which individuals can cope with the stressor and its effects.[72] A comprehensive preparatory information strategy addresses how the person is likely to feel in a stressful setting (sensory information), describes the events that are likely to occur during the transition from normal to stressful conditions (procedural information), and provides

information on how the person can counter the undesired effects of stress (instrumental information).

Although the research looking into the effectiveness of this approach to enhance performance in stressful environments is limited, the early findings are promising.[91] In a study with military personnel, Inzana and colleagues[90] observed that presentation of preparatory information reduced subjective anxiety and improved performance accuracy on Naval decision making tasks. The beneficial effects of the intervention were observed in both a high stress and a normal stress condition.

Although the effectiveness of preparatory information on team performance has yet to be investigated, a promising platform is brought to mind with the recent work in the area of team communication. Lingard and colleagues[92] have shown that a preoperatory briefing with completion of a checklist led to a reduction in communication failures, an increase in the identification of problems and ambiguities, and modifications in the plan of how the case would proceed. Although this intervention did not specifically target team performance during high-stress situations, this sort of intervention holds promise. It could be further examined to determine whether its implementation reduces stress levels, increases shared understanding of the case, and, in doing so, enhances the implicit coordination and team performance during crisis situations.

Stress inoculation training. One promising method of reducing stress responses and performance impairments under acutely stressful conditions is stress inoculation training.[93] This three-phase cognitive–behavioral approach to stress management has proven effective in a variety of settings.[72,94,95] By training effective coping skills before stress exposure, the objective of stress inoculation training is to prepare individuals to respond more favorably to stressful events. The first phase of the training is the conceptual/education phase, in which the goal is to help individuals gain a better understanding of the nature of stress and its effects. The second phase consists of the skill acquisition and rehearsal phase. The objective of this phase is the development and practice of coping skills to reduce anxiety and enhance the individual's capacity to respond effectively to stressful situations. This phase is focused on training the individual to maintain an awareness of stress reactions and to invoke appropriate skills to reduce stress. These skills consist of cognitive restructuring techniques aimed at regulating negative emotions and thoughts and of relaxation techniques to increase control over physiological responses. The third and final phase consists of the application phase. The coping skills are applied in increasingly stressful conditions that approximate the real-world stressor environment.

Stress inoculation training has been found to be effective in reducing general state anxiety and performance anxiety (anxiety specific to the skills being addressed in the training) and in enhancing performance under stress.[95–98] Stress inoculation training seems to be effective when run with groups of 8 to 10 participants, and it can be implemented successfully without an inordinate number of training sessions. Its effectiveness does not seem to be restricted to the laboratory setting, suggesting that it can be effective in applied settings such as health professions education.[94] Finally, the beneficial effects of stress inoculation training can generalize to novel stress conditions and novel tasks,[99] which is crucial for any applied area in which the conditions of real-life environments are often dynamic, ambiguous, and emergent. It should be noted, however, that further research needs to be conducted regarding the extent to which the benefits of stress training will generalize across different stressors and different tasks. Further guidance on how to design stress inoculation interventions can be found in Meichenbaum's[93] and Johnston's[94,95] work.

Conclusions

Health care professionals and trainees are often required to provide care for patients or to learn new information in acutely stressful situations. The effects of stress on performance seem to be determined by the individual's appraisal of the demands and available resources in a situation, by the underlying cognitive processes required to perform a particular clinical task, by the relationship between the stressor and the task, and by mediating factors such as coping styles, locus of control, and social supports. However, more research is required in this area to fully understand the contributions of these factors to performance under stress and to effectively prepare trainees to perform under acutely stressful conditions. Eventually, it will be useful to overlay the stress and stress management literature with other timely topics in medical education such as fatigue and burnout.

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