

Judgment and decision making under stress: an overview for emergency managers

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Abstract: This paper discusses human judgment and decision making under stress. The authors review selected recent literature across various disciplines and suggest a definition of stress within the context of decision making during the management of emergencies. They also discuss fieldwork by the Pittsburgh Research Laboratory, NIOSH, which explores traumatic incident stress, the relationship between previous training and performance under stressful conditions, and human behaviour in underground mine fires. The authors assert that stress is one of the factors that decision makers must contend with in most life-or-death situations. They suggest that a better understanding of individual judgment and decision making activities whilst under stress would yield a better understanding of how people reach the choices they make in emergencies. This enhanced understanding would be of enormous value to emergency managers, researchers and policymakers.

1 Introduction

Clearly, the effect of stressful conditions on human judgment is of importance to emergency managers. In natural or human-induced emergencies, the decisions that are made in the first minutes, hours, and days are critical to successful mitigation; damage control; prevention of death, injury and structural loss; control of financial costs; and, ultimately, the overall resolution of the disaster. The impact of stress on professional judgment is significant. During an emergency situation, critical judgments are frequently made under conditions of acute temporary or prolonged stress. Emergency decision makers are required to process massive amounts of information, which is sometimes incomplete or faulty, usually under severe time constraints.

1.1 Definitions

The use of the term 'stress' is rooted deeply in the literature. Lazarus and Lazarus [1, p.220] discuss the use and definition of the word 'stress' and note that it was used as early as the fourteenth century to mean hardship, straits, or adversity of affliction. In the seventeenth century, a physicist-biologist, Robert Hooke, tried to help engineers design man-made structures such as bridges, which had to carry heavy loads and resist buffeting by winds, earthquakes and other natural forces that could destroy them. An important and practical engineering task, therefore, was how to design bridges to resist these loads, or stresses. Hooke's analysis greatly influenced the way stress came to be thought of in physiology, psychology and sociology – as an environmental demand on a biological, psychological or social system.

One popular current definition stipulates that "stress is a process by which certain work demands evoke an appraisal process in which perceived demands exceed resources and result in undesirable physiological, emotional, cognitive and social changes" [2, p.6]. The authors hold this definition as one of the most appropriate for emergency management purposes, because 'demand exceeding resource' is a key factor, either in the management of an emergency or in the response of an individual. The focus is on the *demand* – which may come from numerous sources including the emergent hazards, other elements of the environment, and social factors – interacting with the human *resource*, which is dependent upon numerous factors including individual perception, physiological constraints, training and experience.

The relationship of stress to judgment and decision making is an aspect of human behaviour that remains inadequately explored [3,4]. The literature in this area is extremely complex and not conclusive. Gillis [4, p. 1355] maintains that:

“while research on 1) the nature and consequences of stress; and 2) human judgment and decision-making are large and varied, there is virtually no overlap between the two despite the obvious practical importance of the effect of stress on judgments...”

Hammond points out that the notion of stress having an influence on judgment was only first broached during a US Congressional hearing in 1988. At issue was compensation for the victims of Iran Air Flight 655, which was shot down by the US Navy cruiser Vincennes over the Persian Gulf. A second hearing was called “to examine the impact of human factors such as stress” on the crew’s performance.

1.2 The Congressional inquiry

Two questions posed during the second Congressional hearing are of interest to this discussion:

- 1 Does the performance during the shooting down identify elements of human behaviour that are poorly understood?
- 2 What have researchers uncovered to date on human ability to make rapid and even complex decisions in high-stress environments? [5].

Four behavioural scientists, identified as expert witnesses, testified and wrote reports to the Defence Policy Panel of the Armed Services in 1989 concluding that we know almost nothing about the extent to which decisions are affected by stressful circumstances, much less the manner in which the decisions are influenced by high-stress environments [3].

The agreement among these experts was three-fold [3]. Firstly, judgment and decision making under stress is an area that has not been adequately studied and we know little about severe stress in group situations. Secondly, it is believed that the competence of human judgment is decreased by stress (even though the experts could not cite empirical data). Finally, the scientists concluded that stress narrows the focus of attention, implying a negative impact on judgment. In hindsight, these experts appear to have been correct only in their first conclusion – that decision making under extreme stress is not a thoroughly studied area of human behaviour. (Hammond disagrees with this conclusion; our divergence with his opinion will be addressed below.) Conclusions two and three are discussed further in this paper, and the authors suggest that the 1989 analysis was too simplistic.

One recommendation of the committee to Congress was that stress needed to be studied further. Meanwhile, the American Psychological Association and the National Institute for Occupational Safety and Health (NIOSH) joined forces in 1990, declaring the 1990s to be the ‘Decade of Stress’. During that decade, resources and attention were focused on increasing knowledge about human stress response and its relationship to numerous variables.

1.3 Paper overview

Over a dozen years have passed since the Congressional hearings on Iran Flight 655, and although no conclusive data on judgment and decision making under stress have emerged, a number of studies have identified topics of interest to those who must make decisions under stress. The research is scattered throughout the social, psychological,

physiological, medical and risk assessment literature, with varying degrees of quality and breadth. This paper presents a selection of these studies with the intention of stimulating a dialogue amongst those managers and others who are responsible for developing models and planning responses that require decision making in disaster situations.

This paper was written prior to September 11, 2001, and has subsequently, been revised. The attacks on the World Trade Center and the Pentagon, as well as the anthrax investigations in offices and postal facilities, created extremely stressful situations for emergency responders. There has been neither time nor opportunity to adequately research these recent experiences with respect to judgment and decision making under stress. Needless to say, these experiences and the potential for future events weigh heavily in the thinking and planning of every emergency manager. Our goal is to contribute to this discussion with an analysis that leads to greater insight into the issues and better questions for continuing research.

2 Assumptions and key issues

2.1 Stress is affected by perception

It is critical to include the concept of perception when discussing stress in relation to performance, including performance in judgment and decision making. The reader should note that in Section 1.1, discussing the definition of stress, the key phrase '*perceived demands*' is used. The ability to cope with stress is dependent upon an individual's perception or interpretation of an event. Gillis [4] suggests that stressful circumstances do not automatically lead to problems in judgment; it is the perceived experience of stress.

An overall review of workplace stress can be found in the International Labour Office Encyclopaedia chapter, "Psychosocial and organisational factors" [6], and in Hurrell and Murphy [7]. Evans and Cohen [8] reviewed human interactions with environmental stressors in detail. For example, uncontrollable cataclysmic events place greater demands on all involved individuals than do minor, albeit emergent, life events. Major disasters press heavily on everyone's resources, and stress reactions are to be expected. The problem is that emergency responders still have a job to do, regardless of the environmental demands and consequent stress. Deciding how to get the job done effectively when critical information is unavailable, or not yet determined, places additional pressure on the individual's decision making process.

2.2 Competence in judgment is always compromised under stress

This particular conclusion of the experts in the 1989 Congressional hearings deserves further evaluation. It is important to note that both *improved performance and performance degradation* have been associated with increased stress [9]. For some individuals, heightened stress elevates their performance. Others are vulnerable to the negative impacts of stress, which results in diminished performance. A physiological example of this positive/negative dynamic of stress is athletic performance. An athlete desiring to be at an optimal performance level whilst competing demands an optimal stress level. The stress level should be enough to stimulate top performance, but not enough to over-stress the body, because performance declines as the body moves toward

exhaustion. This is an example of the ‘inverted-U’ arousal-performance model of stress [8].

Studying the effect of stress on performance and judgment, Dorner and Pfeifer [10] subjected 40 subjects to a computerised forest fire fighting game. Half of the subjects were placed under conditions of stress (a disturbing noise) and the others were left to focus on their task. The exercise involved varying levels of difficulty and lasted five hours. The researchers found that subjects under stress performed equally to those not stressed, but their problem solving patterns were different. Stressed subjects focused on the general outline of the problem, while non-stressed individuals relied on in-depth analysis. Consequently, stressed subjects made fewer errors in setting priorities whilst non-stressed subjects controlled their fire fighting operations better.

Two Greek researchers, Kontogiannis and Kossivelou [11], examined the decision making strategies and cooperation patterns used by proven, efficient teams in adapting their behaviour to cope with stressful emergencies. The authors conclude that stress restricts cue sampling, decreases vigilance, reduces the capacity of working memory, causes premature closure in evaluating alternative options, and results in task shedding. A study of military commanders [12] found that teams with records of superior performance have one common critical characteristic: they are extremely adaptive to varying demands. The teams in their study could maintain performance using just one-third of the time usually available to make decisions, but the mode of communication changed. Initially, the team responded to explicit requests in communications from commanders. As time pressure increased, they stopped waiting for explicit requests and instead provided commanders with information they implicitly determined would be useful.

Serfaty and Entin [12] suggest that changes from ‘explicit’ to ‘implicit’ communication can help teams maintain performance under time pressure. Implicit coordination patterns, anticipatory behaviour, and redirection of the team communication strategy are evident under conditions of increased time-pressure. The authors conclude that effective changes in communication patterns may involve updating team members, regularly anticipating the needs of others by offering unrequested information, minimising interruptions, and articulating plans at a high level in order to allow flexibility in the role of front-line emergency responders. The authors found support for the main hypothesis that team coordination strategies will evolve from explicit coordination under low workload conditions to implicit coordination as work load increases.

High reliability organisations exhibit a similar flexibility [13]. Aircraft carriers, nuclear power plants, and similar organisations operate under conditions of extreme hazard, with little latitude for failure. Organisational structures, functions, and a safety climate that promotes rapid and effective communication are critical to maintaining safe work practices [14].

2.3 Stress is related to information

In studies of escape from underground mine fires, researchers have identified several human behavioural and organisational dimensions relevant to understanding decision making under duress. Firstly, initial warnings in dangerous situations are often unclear, sometimes due to the way technology behaves and sometimes due to faulty communication. This can lead to different interpretations of the problem. Secondly,

people frequently fail to gather the right kinds of information, which prevents them from making appropriate responses. Thirdly, once a decision is made, individuals respond well to a leader, however, if leadership is lacking, people tend to become confused. Finally, apparatus (e.g., those used in mine emergencies) may not work as expected or may fail. Thus, emergency decision makers under stress not only have the effects of their own stress response and its resulting consequences, the information they must base their judgments on is often unclear, faulty and incomplete [15].

2.4 *Stress narrows the focus of attention*

A primary conclusion of the experts at the Congressional hearing was that stress narrows one's focus. Time pressure studies, where the subject is given a task and a specific, usually unreasonable, time to complete it, generally support this conclusion. Other studies, however, report contradictory results for this conclusion [3]. *Negative information gains* become important under time pressure because they need to be evaluated and discarded. If a situation involves *risk* (as in response to an emergency), time pressure studies show that the subject becomes more cautious and adopts risk-avoiding behaviour with importance placed on *avoiding losses* [16]. These studies have shown that, under time pressure, the subject *adopts a simpler mode of information processing* in which alternatives are not explored fully and certain important 'cues' are used to determine the decision. From these studies, the experts conclude that stress *narrows the focus of attention*. In other words, the focus of attention shrinks, and the individual focuses just on critical issues and elements. This focused attention was assumed to be bad, but it actually may be good because it can eliminate nonessential information and highlight the most important sources.

Citing two studies reported in 1993, Gillis [4] did not find support for the 'narrowing of attention' hypothesis. Keinan *et al.* [17] tested the proposition that deficient decision making under stress is due largely to an individual's failure to fulfil adequately a most elementary requirement of the decision making process, i.e., the systematic consideration of all relevant decision alternatives. In their study, which required participants to solve problems whilst under stress, one group was put under stress and compared to a non-stress control group. Stress was found to induce a tendency to offer solutions before all decision alternatives had been considered and to scan such alternatives in a non-systematic fashion.

2.5 *Dynamic environments impact on decision making*

According to Kerstholt [18], decision making behaviour is considerably affected by the dynamics of environment, because most natural dynamic situations contain much uncertainty. He notes that a dynamic situation continually changes and, thus, a decision maker has to take temporal changes into consideration. He further notes that a decision maker can use feedback on the effect of his/her actions on the system. In other words, as decisions are made and action is taken, the results of the decision may be taken into consideration and the information used in subsequent decisions. Additionally, in dealing with the uncertainty of a continually changing environment, the decision maker must achieve a trade-off between the cost of action and the risk of non-action.

To test his hypothesis, Kerstholt conducted a computer experiment in which subjects had to control a system that changed over time. In this experiment, the subjects had to monitor the continuously changing fitness level of a simulated athlete, and prevent him/her from collapsing. Information requests were treated as costs in the subjects' incentive system, and correct treatments were treated as benefits. The decision making strategy remained constant. False alarms and 'real' changes in system parameters represented sources of deterioration in the system. Time pressure in the study was related to the development of the situation itself, and the allocation of time had to be correlated to the risk of negative consequences and the cost of delaying further information requests. The results showed a general speeding up of information processing as time pressure increased. Under high levels of time pressure, this strategy led to a significant increase in system crashes.

It is interesting to note that requests for information were not congruent with conditions – subjects tended to wait until an already deteriorating situation had further deteriorated before acting. It can be assumed that, if information is expensive in time and actions are cheap, subjects will be more inclined to use an action-oriented strategy. To the contrary, subjects did not select the most efficient strategy – they chose further information over action. Results indicated that selection of a decision strategy in dynamic tasks is less adaptive than is generally concluded from studies with static tasks.

Kidd *et al* [19] linked stress and injury in another dynamic environment – farming. In a three-step secondary analysis of focus group data, one of their conclusions stated: the dimensions of workload that were particularly important included job and task complexity and lack of time. Both of these dimensions are relevant to the emergency worker. Further, as a preventative measure, the researchers suggested that a decrease in the number of roles performed exclusively by a single farmer during busy seasons could improve safe work practices and contribute to successful task performance.

2.6 *Stress affects behaviour in emergencies*

There are limited studies regarding *the effects of stress* on behaviour in emergencies. Researchers working with the US mining industry have explored the issues of traumatic incident stress in mine disasters [20], burnout [21] stress levels related to training during a simulated escape through smoke [22], and behaviours in underground mine fires [15]. In the training study, small groups of miners were required to don self-contained self-rescuers (breathing apparatus), enter an area of an underground limestone mine that had been filled with non-toxic theatrical smoke, and travel approximately 270 metres to a door, through which they exited into fresh air. Individual subjects then provided a self-report of their experiences on questionnaires administered immediately upon completion of their walk through smoke. The general finding was that miners who had more experience or training also tended to report less stress during the exercise.

In the study of worker behaviours in underground mine fires, researchers examined eight cases in which groups of miners had escaped their workplaces through smoke. One goal was to determine whether it would be possible to model those factors that impact on one's ability to make good decisions during an emergency. The researchers suggested that any person engaged in decision making is actively involved in a process characterised by certain elements:

- 1 detection of a problem
- 2 definition or diagnosis
- 3 consideration of available options
- 4 choice of what is seen to be the best option given the perceived needs
- 5 execution of the choice based on what has transpired.

At any moment in this process, several factors significantly impact one's ability to solve complex problems in a limited time:

- 1 psychomotor skills, knowledge and attitude
- 2 information quality and completeness
- 3 stress – generated both by the problem at hand and any existing background problem
- 4 the complexity of elements that must be attended to.

The resulting model posited interactions amongst the major components, so that heightened stress, for instance, might interfere with an accurate diagnosis, whilst an accurate diagnosis would lead to lowered stress levels.

2.7 Laboratory studies vs real-world experiences:

Hammond [13] stated that he believes there is a substantial body of research on decision making under stressful circumstances. As noted above, we challenge Hammond's interpretation, but this disagreement is more likely to be a question of definition: what exactly constitutes a study of decision making under stress? Do the laboratory results of task performance under severe time constraint, for example with a loud noise, readily generalise to emergent conditions where the consequence of failure is that someone is injured or killed? The problem for experimenters is that it is dangerous and unethical to conduct experiments in truly hazardous or harmful circumstances. The problem for external validity is that minor stresses in the laboratory may be fundamentally different from life-threatening conditions in the real world. Thus, whilst we recognise that laboratory studies often represent the best approximation of stress that can be achieved, this research should continue with more comprehensive follow-up assessments of experiences of emergency crews in the field (e.g., [15]).

3 Analytical vs. intuitive judgment under stress

There is an assumption that the best decisions are rational – based on logic and factual information. This assumption has implications for the discussion of judgment and decision making under stress. Researchers have tended to look at reason and emotion separately. A value has been placed on decisions made with reason: “. . . it is a careless – but common – usage to suggest that when we make bad decisions, they are based on emotion, but when we arrive at good decisions, they are based solely on reason” [1, p. 199]. Hammond posited that different situations demand different forms of cognitive activity, some calling for increased analytical cognition, and others calling for increased

reliance on intuition. Both the environmental conditions and people's reactions to them are key as we learn about judgment and stress.

It is instructive to examine some instances of judgment under stress in which decision makers followed different paths but achieved successful outcomes. Hammond [3] describes the following:

Case 1: The USS Samuel B. Roberts, operating in the Persian Gulf, struck a mine, caught fire, and began to sink. The Roberts' captain, Commander P.X. Rinn, drawing upon his training and experience, analysed the situation and determined a course of action directly opposed to Navy protocol. From his knowledge of how much water the ship could take on and still stay afloat, Rinn realised that the Roberts would sink before his crew could extinguish the fire. Commander Rinn made the decision to focus on keeping the ship afloat and give the fire second priority. He is on record as having arrived at his decision analytically, based on available information, training, and operational experience.

Case 2: A United DC-10, on its way from Denver to Chicago, lost its hydraulic fluid and, hence, its controllability. Captain Al Hayes and his crew had to discover an alternative way to fly the plane by using the throttles – something their training had not prepared them for – and do it with few of the cues usually available to pilots. That they were able to land with minimal loss of life may be attributed to intuitive decision making under stress.

The two cases cited by Hammond portray decision making in life-threatening circumstances under two distinct scenarios: one where the knowledge and training of the decision maker were readily applicable, and one where the decision makers' training had not prepared them for the exigency they faced. Yet, both instances involved individuals who *were* highly trained. In many dynamic settings, such as mining, those who are forced to make decisions in emergency situations have little training. This is because mines, fishing boats, and logging operations, amongst others, are dedicated to production activities rather than to emergencies. Thus, their personnel may have had minimal exposure to potential crises. Their decisions must, almost of necessity, be based on intuition or fragmentary knowledge.

Considering this issue of analytical vs. intuitive judgment, a NIOSH [15] report observed:

“The point here is that research which focuses on judgment must include scrutiny not only of decisions that are made, but also of real-world variables that influence them. The quality of any decision may have little or no direct relationship to the eventual outcome of its execution in a given situation. This is because a decision-maker is constrained not only by the stress of the situation or personal knowledge and attitudes, but also because he or she can only weigh information that is available.”

Acknowledging the complex context of decision making environments and their various sources of stress is a first step to understanding the process of decision making and learning to evaluate the abilities of decision makers.

4 Conclusions and observations

Growing research interest has led to the question of what factors influence a person's ability to make good decisions during an emergency. There is still little agreement on

how to define those basic concepts – including stress – that are necessary to assess the soundness of decisions with respect to both environmental and group contexts. Real-world, high-risk occasions and emergency situations create the need to better understand judgment and decision making under stress. The fundamental assumption is that, whilst there are untold successes, there are also notable failures resulting from decisions that can be ascribed to one or more errors of judgment. What part, then, does stress play in the commission of these errors? This is a question for further inquiry. We accept that from a cognitive perspective, any person engaged in decision making (either alone or in a group) is actively involved in a process characterised by certain elements. At any moment in this process, there are factors that have a large impact upon one's ability to solve complex problems in a limited time. Stress is one of those factors.

So what is the advice for the emergency manager based on the data? Unfortunately, the authors cannot offer a 'list' of factors to consider in judgment and decision making under stress. The present, limited data do not support such an approach. There are serious limitations to generalising from laboratory studies to real-life emergencies. We know that there is an interaction: stress affects human decision making. What we do not know is the exact nature of this interaction.

The research suggests that successful teams communicate amongst themselves and, as the emergency intensifies, a flatter communication hierarchy develops with more (unsolicited) information coming from the field to the command centre. Command centre personnel can facilitate and encourage this type of information.

Stress is affected by perception; it is the perceived experience of stress that an individual reacts to. However, extremely hazardous emergent environments will create some degree of stress reaction in every worker present. A common approach by emergency managers is to minimise stress for the responders through pre-event training. The key question is: what is the best form for this training to take?

Contrary to popular opinion, judgment is not always compromised under stress. Although stress may narrow the focus of attention (the data are inconclusive), this is not necessarily a negative consequence in decision making. Some studies show that the individual adopts a simpler mode of information processing that may help in focusing on critical issues. Decisions can only be made based on the information available, and studies have shown that, on many occasions, decisions are made with incomplete information. In addition, the issue of training plays a part in stress and decision making.

Regarding the development of decision support systems, the authors offer several suggestions. Decision support programs should be tested under conditions of stress (time pressure is one option) to evaluate their effectiveness. Simulations should be used to replicate stress conditions in the field. New simulations should include a stress component, taking into consideration the issues presented in this paper. A simulation should also take into account the increased need, as an emergency progresses, for explicit and implicit information to be received from the field and integrated into the decision making process. Because simulation exercises cannot replicate the hazardous nature of emergent events, the simulation studies need to be confirmed through observations of emergency personnel and through follow-up discussion. Investigations of actual events can begin along several dimensions:

- 1 the nature of the hazard, including severity, speed and potential for control [23]
- 2 information, including degree of availability/completeness, analytic and problem-solving strategies, identification of needed information and new questions, and effectiveness of communications
- 3 the resources for bringing the hazard under control, including the likely effectiveness of the control efforts
- 4 the timeframe in which decisions have to be implemented and efforts completed
- 5 the severity of physical and emotional stressors present in the environment and the likely stress reactions that may develop.

This paper has suggested that a better understanding of the interplay between stress and an individual's judgment and decision making activities would yield a better understanding of how people reach the choices they make in emergencies. As far as studies of judgment and decision making are concerned, the limited literature in this area suggests a strong need for increased attention to the topic.

Stress is one of the key factors that underlie the demands on decision makers in most life-or-death situations. Whether the individual is a naval commander, an airline pilot, a mineworker, or an emergency manager who has access to a decision support system, an emergency makes it necessary to deal with an enormous number of variables in a rather short time frame.

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