THE BEHAVIORAL SCIENCE CONTRIBUTION TO EMERGENCY MANAGEMENT AND ENGINEERING

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Nature may turn out not to be organized into disciplines in quite the same way as universities are - Ackoff

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ABSTRACT

This paper discusses the importance of behavioral science disciplines to emergency management planning and engineering. The authors argue that most emergency response situations, whether simulated or real, occur in systems characterized by both psycho-social and technical components. Those who design emergency systems, whether these are evacuation techniques, decision support technology, fire fighting equipment or other specialized apparatus, often make inexpert assumptions about human behavior. These underlying opinions in turn influence the designers' technical output. Knowledge of the behavioral sciences can provide empirical information, not only on general human response patterns, but about individual and group behavior during emergencies as well. This information allows for more accurate planning and development of system designs. In addition, the behavioral science disciplines can add their empirical tradition to emergency management and engineering, thus providing a template for testing models experimentally.

INTRODUCTION

One consequence of our post-industrial shift toward an information transfer society has been the increasingly complex nature of most human-made systems. Knowledge about these systems based on a Newtonian world view, e.g., that things and people can be divided into discrete categories and controlled, is now being disputed in many arenas. The reason for this wholesale challenge to existing paradigms lies in the fact that they assume a certain amount of independent predictability. When predictions aren't borne out, the explanatory frameworks that rest upon them are in turn brought into question. As systems become ever more intricate, then, their comprehension demands greater levels of sophistication. Insights from any one discipline may now be inadequate to meet these needs.

This concern was expressed by Ab van Poortvliet, et al. (1994:97) in relation to risk management. The authors claimed that most safety issues have been studied from a single discipline perspective. A major drawback to such one-dimensional thinking is that some problems are ignored completely and others do not get resolved. Consequently, planning for large scale incidents involves as much guesswork as anything else. Van Poortvliet and his colleagues thus called for a more comprehensive, interdisciplinary, approach to safety management.

The first step toward achieving a holistic view of emergencies, which happens to be the focus of this article, is recognition that "... the problem nearly always involves working with a total integrated organizational unit" (Herbst, 1974:86). It is extremely difficult, if not counterproductive, to unravel technological, psychological and social factors in describing the causes and responses attending any large-scale real world event. What we need, therefore, is a perspective that specifically rejects our tendency to view problems with the tunnel vision fostered by a particular discipline.

To some extent, socio-technical system theory offers a remedy for one-dimensional thinking. This theory is guided by two principal concepts. First, most task-oriented situations involve a social system of people needed for certain work and a technological system made up of the tools and techniques necessary to get the work done. Second, these interrelated systems of people, tools and activities are in turn part of a larger environment that influences (and is influenced by) the socio-technical system. This open-structure approach to real world situations highlights the need for a basic understanding of organizational phenomena actively and comprehensively rather than passively and piecemeal.

However, one problem with socio-technical system theory, at least in practice, has been the tendency of researchers to focus upon ways to bring a recalcitrant social system in line with an optimized technical layout rather than trying to determine a joint optimization for both (Kelly, 1978). A major reason for this bias lies in the fact that human behavior is seen as too bewildering to predict reliably: "The result is that we are able to specify in considerable detail the requirements of the technical system, but we have no adequate way of describing the social system let alone identifying its characteristics" (Cherns & Wacker, 1978:823).

Yet, as technology gets increasingly intricate and more dependent on information transfer, the need to understand how social systems function will become greater. This demand ought to be especially acute in the area of large-scale emergencies (Robinson, 1982), because the human element is implicated in many "normal accidents" (Perrow, 1984) that occur in complex systems. What alternative exists, then, to taking the social system as a given?

Herbst (1974:88) suggested a very intriguing multiple-perspective model. Rather than viewing any event as composed of physical phenomena on one hand and psychological or social occurrences on the other, he argued there are no exclusive properties: "Every event can be analysed with respect to its role within a network of physical relationships or with respect to its role within a network of psychological relationships, or with respect to its role within a network of sociological ... relationships."

Instead of looking for a way of linking two disparate things, then, the researcher using Herbst's approach would simply need to determine in what way the different modes of analysis used to understand an event are related to one another. In other words, he or she ought to assume the role of *interdisciplinary coordinator*. In that way, the researcher can draw upon various sources of expertise to illuminate a particular problem area.

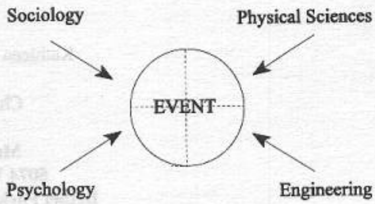

Figure 1: Understanding an event from a sociotechnical perspective

The behavioral sciences have much to offer emergency management and engineering in a multiple-perspective model such as Herbst envisions. First, behavioral scientists helped to develop general systems theory, which fits well with ideas of the socio-technical school. Second, and perhaps as important, behavioral scientists have studied human response to emergencies. In the section following we look at some of these studies and suggest how they might be coordinated with engineering and physical science perspectives on large scale accidents.

INSIGHTS FROM THE BEHAVIORAL SCIENCES

Traditionally, as we know, most emphasis has been on the engineering and mechanics of a disaster though some technical design studies have included the human element. An example is "Time of Evacuation by Stairs in High Buildings" (Galbreath, 1969), which focused on the movement of people. However, it did not consider such variables as evacuation speed, or other factors that might influence choices of direction. Historically, then, human behavior was "fit" into the appropriate "bits" found suitable for an engineering paradigm.

Grosdeva and Montmollin (1994) performed numerous studies to analyze what happens when nuclear plant operators are confronted with technical malfunctions. These authors put more emphasis on the operator's qualitative competence (knowledge and reasoning) than upon the quantitative reliability studies which measured their actions. Grosdeva and Montmollin believe that while the latter can inform us about ill-fated behaviors, the former will yield important information about *why* the actions were taken. When the *why* of human-machine problems is sought, we move beyond a mechanistic representation of human response and enter the domain of the behavioral sciences with their empirically sound methods for testing procedures.

What can the behavioral sciences contribute to the emergency field that will allow us to go beyond simplified representations of people's responses? What kind of useful information might a system designer glean from a systems approach that embraces the tenets of human behavior? To address these questions, this section will focus upon a brief overview of studies that deal with three different dimensions of actions during critical events: the notion of group effects; leadership in escapes; and panic behavior.

The Notion of Group Effects

Human behavior may be viewed from an individualistic perspective - traditionally the focus of psychologists, or from a group interaction perspective - the interest of social psychologists and sociologists. Generally, disasters involve groups of people who are interdependent during escape, meaning that there is a need for people to work together to escape or evacuate.

Studies were reported by Kelley et al. (1965) on laboratory simulations of one type of group escape situation. Each group of subjects was given a limited amount of time to escape from an electric shock by depressing an escape switch that only worked if other members of the group were not pushing theirs. They were able to escape only one at a time thus creating a situation of mutual dependence. The researchers found that when members of a group took their cues from each other, one of two things happened: if there was little optimism about escape, interaction proved to be harmful; but a high level of optimism was reinforced by interaction and resulted in successful escape. In addition, the authors found that public expressions of confidence reduced anxiety and greatly increased the percentage of people who managed to escape. If there was a sign from one or more subjects that they were willing to wait, successful escape increased.

The "Affiliative Model" (Sime, 1983) predicts that in life-threatening situations individuals will be concerned not only with self preservation, but will experience an increased concern for other group members. McPhail and Wohlstein (1983:594) supported this notion in their work suggesting that "... most individuals assemble and remain with friends, family or acquaintances. Those social units constitute sources of instruction and sanctions for the individual's behavior." Turner and Toft (1989:177) pointed out that during the Summerland Leisure Centre fire individuals based their actions on family group membership: "Instead of immediately escaping themselves, ... many parents desperately looked for their children frequently causing additional confusion ..." The authors concluded that "... individuals with close psychological ties will attempt to escape in groups of two or more."

Similar findings were reported in the study of the Beverly Hills Supper Club fire (Johnson 1987). Interviews showed that even when family relationships weren't present the survivors reported escape by groups and frequently used the names of others in describing their escapes.

The presence of other people influences responses and response time. It has been suggested that attachment or affiliative behavior has survival value (Bowlby, 1973 in Sime 1983). Gaining proximity may be interpreted as providing a protection from threat. Knowing that people tend to seek out others in a crisis provides the emergency planner with important data. Humans do not escape four abreast down a stairwell at the first indication of an emergency. In planning evacuation time, needs, and equipment, human interaction in crisis must be taken into consideration. In addition, the interaction between people is important in the choice of exits as people tend to follow the route that others are using (Hodgkinson, 1990). Thus, in reality, people will not divide into equal groups utilizing each available exit, as in the model of "bits" of human behavior engineered to fit the situation.

Leadership Behavior in Escape

Simulation models have been created to study human response (specifically leadership behavior) in emergencies. Hayashi (1988) created a computer simulation model to aid in planning disaster prevention by evaluating leader behavior in a fire. The model was designed to judge the actions and thinking of leaders. The simulation consisted of a maze with a leader, an informal leader and 50 evacuees. This simulation was run four times each by 101 subject-leaders. The results indicated that the leader actions were not dictated by circumstances but by the individual characteristics of each leader, leading the author to conclude that an evacuation plan should not be based on circumstances but should consider the anticipated behavior patterns of leaders. In addition, the study showed that the worse a situation gets the less salient are individual differences.

What can this mean to emergency managers - to base an evacuation plan on the *anticipated* behavior of leaders, not on circumstances? This is exactly the type of recommendation from the behavioral sciences that creates consternation for the emergency manager. Yet, knowing that effective escape leaders make decisions logically - based upon available information, the manager can evaluate the probable information available to the escapees and *anticipate* logical behavioral responses thus fulfilling the role suggested in Herbst's model, of the interdisciplinary coordinator.

An analysis of leadership behavior during escape from several U.S. underground mine fires resulted in a profile of six leadership characteristics. The leader of each escape was described as an aware, knowledgeable person, alert to his environment, attentive and discerning whose leadership emerged in a natural way. The leaders were decisive, yet flexible and open to input from others. Effective leaders seemed to have a calming effect on their group. Finally there was a logic to their leadership; logical decisions based upon available information (Kowalski et al., 1994).

Panic Behavior

The panic model says that people will revert to highly primitive, self-preservation behavior, ie., "every man for himself." This inaccurate assumption, accepted as a general human response pattern, has figured implicitly or explicitly in fire regulations. Contrary to "common belief", however, panic is not automatic in fire or other crises (Johnston and Johnson, 1988; Hodgkinson, 1990).

In a laboratory computer simulation Misumi and Sake (1982) used one accomplice leader and four naive subjects. Each subject could move his or her assigned red dot on a display. The results indicated that if the leader first attempted to reduce tensions and then indicated the direction of escape the subjects followed more closely than if the sequence of behaviors was reversed. The authors concluded that panic is reduced by introducing appropriate leadership.

There are many variables that mitigate the "contagious emotion" that is usually defined as panic. In fact, researchers have generally concluded that individuals will panic and try to save themselves at the expense of others *only* when a situation is *extremely* threatening (Sime, 1990).

DISCUSSION

Clearly, the behavioral sciences can contribute important insights to those charged with managing emergencies. The research presented here, for instance, supports the contention that emergency activities (including escape) are not individualistic, they tend to be group responses... thus we must look toward models based upon group interaction data. In planning for emergencies we must take into account the anticipated behavioral pattern of collectivities (Levit, 1988). The behavioral sciences can offer this piece to a total systems approach.

Yet, it is short-sighted to simply add new disciplines and information or divide the various functions of emergency management into "bits" to be entered with the expectation of producing a "whole". In true systems philosophy, the sum of the parts is greater than the whole. A socio-technical approach challenges the manager with the task of coordinating the *gestalt* of a multi-disciplinary endeavor.

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