Why People 'Freeze' in an Emergency: Temporal and Cognitive Constraints on Survival Responses

Aviation, Space, and Environmental Medicine • *Vol. 75, No. 6* • *June 2004*

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Background: Many witnesses attest that victims of a disaster often perish despite reasonable possibilities for escaping because their behavior during the initial moments of the accident was inappropriate to the situation. Frequently witnesses report victims 'freezing' in the face of danger.

Objective: The aim of this paper was to identify the possible factors underpinning 'freezing' behavior in disaster victims.

Methods: Witness testimonies, survivor debriefings, and official inquiry reports from shipwreck and aircraft emergencies were analyzed for their behavioral content.

Results: It was found that 'freezing' behavior was a frequently cited response by witnesses to a disaster. 'Freezing' causes evacuation delays which increase the danger, establishing a closed loop process and further extending evacuation delays. This behavior can be accounted for by considering the temporal constraints on cognitive information processing in a rapidly unfolding, real-time environment.

Conclusion: Cognitive limitations help to explain why survival training works and why there is a need for a survival culture to be developed. They also highlight the need to understand the behavior of children under threat as being different from that of adults due to the different stages of their neurological and cognitive development. There are implications for the development of proactive, rather than passive, life support equipment.

We often hear about life-threatening or fatal disasters involving aircraft, ships, oil platforms, and other large, engineered structures. Although many crashes or other disasters offer no chance of escape, others allow for at least some survivors. Over the years, witnesses to a variety of disasters have testified to seeing victims die who could have escaped had they responded appropriately to the emergency.

It is commonly held that, faced with a threat to life, an individual will tackle the situation either directly or by taking evasive action: the classic 'fight or flight' response. Systems for escape, evacuation, and rescue are designed on the assumption that people will be proactive in the face of danger. Failure to act (immobility or "freezing") is an impaired response that delays evacuation, establishing a closed-loop process that leads to fatalities in otherwise survivable situations. This paper presents evidence that freezing is a common response to unfolding emergencies, and examines the implications of this phenomenon for training and the design of equipment to save lives.

METHODS

The author analyzed official inquiry reports and written witness testimonies from five maritime and six aircraft disasters to determine whether victims appeared to freeze. The following incidents were included in the review: emergency evacuations from three offshore platforms including Alexander Kielland (capsized in 1980 with 123 dead, 85 survived), Ocean Ranger (sank in a storm in 1980 with 84 dead)*, and Piper Alpha (explosion and fire in 1988 with 167 dead, 69 survived); the sinking of the ferry, MV *Estonia* (sank off Finland during a storm in 1994 in which 852 died and 137 survived) (6); and a fire on a Boeing-737 (runway engine fire at Manchester Airport, UK, in 1995 in which 55 people died and 82 survived) (1). In addition, the author interviewed 19 survivors (17 male, 2 female) of 3 shipwrecks and 4 different aircraft emergencies concerning their own responses and those of others around them. The initial interview was open followed by structured questions. At no time were the survivors asked specifically about 'freezing' behavior.

RESULTS

The official report of the circumstances surrounding the aircraft fire at Manchester Airport (UK) in 1995 in which 55 people died (1) stated that the danger of death was '. . made more critical by evacuation delays.' The report continues, 'The major question is why the passengers did not get off the aircraft sufficiently quickly.' Interestingly, an empirical study into passenger evacuation from an airliner reported seeing volunteers who were 'behaviorally inactive' (8). Similarly, the official report of the *Estonia* sinking reported that many people were '. . . passive and stiff, despite reasonable possibilities for escaping' (6). It is clear from an analysis of the victims' behavior in the Manchester crash that many From the Department of Psychology, University of Lancaster, Lancaster, UK.

DISCUSSION

This freezing response has been ascribed to various causes: shock, paralysis, horror, etc. These, however, are descriptions rather than processes and the question still remains concerning the nature of the mental process of 'freezing' in the face of danger. If this impairment can be modeled, then predictions about behavior can be made and countermeasures devised to assist in the saving of lives. This paper presents the first steps in the development of such a model.

The reports and survivor interviews all described behaviors consistent with previously reported natural histories of disasters (7) at both the group and the individual levels. Responses to unfolding disaster can be divided broadly into three groups. In the first group, between 10–15% of people will remain relatively calm. They will be able to collect their thoughts quickly, their awareness of the situation will be intact, and their judgment and reasoning abilities will remain relatively unimpaired. They will be able to assess the situation, make a plan, and act on it. The second group, comprising approximately 75% of the population, will be stunned and bewildered, showing impaired reasoning and sluggish thinking. They will behave in a reflexive, almost automatic manner. The third group, comprising 10–15% of the population, will tend to show a high degree of counterproductive behavior adding to their danger, such as uncontrolled weeping, confusion, screaming, and paralyzing anxiety (4,5,7,10). Human responses to unfolding emergencies and the tendency to freeze can be understood in terms of neurocognitive function and the time required to process the several steps between perception and appropriate action. The brain is a multi-channel, limited-capacity signal processor which has built-in temporal constraints that affect its ability to operate in a real-time emergency. Operational information is processed in working memory, which has two important limitations:

1) it can hold only so much information at any given time; and
2) it can process information at a given maximum rate and no faster. The consequence is that higher order human cognition under optimal conditions requires a minimum of 8–10 s for completion (2,9).

The more complex the cognitive task, the more expansive the neural circuitry needed, and the more likely that processing time will exceed the minimum. Non-optimal circumstances, such as danger, may further slow information processing. This helps to explain the slowing or absence of response during the critical impact phase of a disaster. There is a sequence in cognition: perception -→ comprehension -→ decision -→ implementation -→ movement. Each element in this order requires its own time to completion. During a disaster, events tend to be both unpredictable and rapid, leaving little or no time for deliberation. Clearly, the faster a person can respond to the unfolding events, the greater are the chances of survival. The brain is structured in such a way that response time can be improved through practice, training, and experience in advance of any disaster. Such preparation involves converting complex cognitive operations (which take 8–10 s) into simple cognitive operations (which take 1–2 s). This process underlies all learned behavior from playing a musical instrument to escaping from a submerged and inverted helicopter. If the response has been learned, the brain no longer requires deliberation or higher-order cognition to compose the correct schema, but has only to select between a set of pre-learned responses. The brain can make this sort of decision successfully within 1–2 s. This conversion of a series of complex operations into one simple operation overcomes the limitation on storage capacity within working memory. One drawback is that this schema of learned response can only be recalled and implemented in the manner in which it was learned. To restructure the activities would involve decomposing simple cognitive operations into their complex components with consequent reversion to loading on working memory capacity. In a developing disaster, events move fast and success will often go to those who can respond quickly and appropriately. One *Estonia* passenger who was interviewed reported that during impact, 'I didn't think. Shock is so disorienting it doesn't allow us to think clearly. People just sitting in complete shock and me not understanding why they're not doing something to help themselves. They just sat there and being swamped by the water when it came in.' Indeed, emergency evacuation is not just about speed. If victims do not respond, then an evacuation system that requires action will not save them. 'One witness saw around 10 persons lying on the deck near the bulkhead. They seemed apathetic and he threw lifejackets to them. He did not see them react or put on the lifejackets' (6). The functional implications for a disaster victim are as follows:

1.) If an appropriate response to such an event has been prepared and embedded in the cognitive database of behavioral schemata, then the speed of response can be as fast as 100 ms. This is an immediate action.
2.) If more than one possible response is available, then choosing the correct behavioral sequence requires simple decision making, which can take 1–2 s.
3.) If no appropriate response exists in the person's database, then a temporary behavioral schema has to be created. This will take at least 8–10 s under optimal circumstances and much longer under threat. The result is that no behavioral schema will be triggered from the schemata database and no temporary schema can be created within the time available. This produces a cognitively induced paralysis or 'freezing' behavior

Tellingly, the *Estonia* report describes passengers who '. . could find no options for rational action,' nor, it is suggested here, could they create one. The clear implication is the importance of training in survival procedures. At the intuitive level this seems obvious: it has long been known that appropriate training works, which is why the military and civilian aircraft and maritime industries insist on survival training and re-training for their personnel. What is only now becoming apparent is the manner in which training works; namely, by providing the temporal and working memory capacity necessary to create a temporary schema of actions, to assemble those actions into the correct sequence, and then to combine those actions into a composed whole, thus reducing cognitive storage and processing demands. Once this process has been completed, an environmental danger signal can trigger the appropriate composed response to aid survival while avoiding an overloaded working memory system. Clearly, lives could be saved if these principles could be applied to passengers or others who are involved in a disaster. However, while formal survival training may be affordable and productive for the military and certain civilian industries, such as the offshore oil industry, trying to apply the same concept or approach to the general public may be counterproductive. Forcing airline passengers to undergo formal survival training may increase resistance and denial among the passengers, increase costs for the companies, and drive away trade from commercial organizations. It would, however, be worth exploiting indirect training and marketing of survival concepts. A first step might be to require airline passengers sitting next to escape hatches to demonstrate their understanding of escape procedures such as opening escape hatches. A cognitive failure in this area was observed during the evacuation of the aircraft at Manchester airport when urgent action was required by the passengers to open the right over-wing escape hatch. The incident report states that it took 45 s to open this hatch, a delay '. . .contributed to by the adjacent passenger's lack of knowledge of the hatch opening procedure' (1). No schema of behavior relating to hatch opening existed in this passenger's database, so she had to create one, and this took time. Given that most types of observed behavior do not support survival, proactive rather than passive rescue devices should be developed that can actively seek out and assist victims. This is not beyond the realm of modern technology, materials, robotics, computing science, and artificial intelligence. The restricted capacity of working memory and the consequent impairment in cognitive function under threat indicates a need to redesign lifesaving equipment to enable a better goodness-of-fit within the system. 'Many passengers reported difficulties with the lifejackets,' '. . .a common opinion was that most witnesses did not understand how to use the lifejackets or how to put them on, they did not seem to fit' (6). The issue of equipment usability was raised by the authors of the Estonia report, who stated the Commission's opinion that '. . .the design of lifejackets should be simplified so that their proper use appears self-evident even for untrained people.' A starting point for such development should be an analysis of the system limitations within which lifesaving equipment has to operate: environment, task, and cognition. I would argue that, as well as the physical environment, the 'threat environment' also needs to be addressed. How children behave in a survival situation is a subject that has received little attention. There were 15 children under 15 yr of age on the *Estonia* when it sank and the report states that, 'Many screams and calls for help, including children's voices, were heard all around the rafts.' One child, a 12-yr old boy, survived. The only children to survive the Manchester aircraft fire were those who were actively rescued by adults. In the design of survival and rescue equipment, the child tends to be either forgotten or considered a miniature version of the adult. From a survival perspective, children should be acknowledged as functionally different from adults due to their neurological and cognitive development. It is clear from many accident reports that most people did not know how to fit or operate a lifejacket. This lack of knowledge appears to be even more pronounced in children. This situation could be remedied by instructing children in the use of lifejackets and other survival devices while at school. After all, children do undergo other safety lessons as part of their normal schooling (e.g., road safety drills). Furthermore, children seem to adopt a safety culture more readily than adults. For example, the wearing of bicycle helmets by children is now almost universal and occurred long before legislation was introduced, whereas adults (in the UK at least) had to be compelled through legislation to wear motorcycle crash helmets and car seatbelts. Once lifejacket skills and a self-rescue culture have been adopted in childhood, appropriate safety drills would be readily accepted later in life. Another advantage of instilling this behavior in children is that it overcomes the denial that prevents construction of appropriate cognitive schemata. In conclusion, freezing behavior was witnessed in many victims. Indeed, so common were the reports that it can be argued that the classic response to danger should be restated as, ‘fight, flight, or freeze.’

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