

## WORKER RESPONSES TO REALISTIC EVACUATION TRAINING

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This paper discusses the data collected during an emergency evacuation training exercise at an underground mine in the United States. The focus of this paper is on the human reaction to smoke and the use of personal protective equipment. Specific issues related to the human stress response during an emergency will be discussed.

### Background

From the early days of coal mining in the United States, workers have been taught to barricade themselves in the event of an explosion or fire underground. Barricades often were constructed crudely from whatever materials were close at hand, and frequently failed to protect trapped individuals from the contaminated mine atmosphere. Until the last decade, however, when caught in contaminated air, miners had few alternatives.

In the early 1980's, though still taught as part of annual refresher training under 30 CFR 48, barricading became devalued as a survival strategy. The reason for this shift was the universal deployment of oxygen generating breathing apparatus. These apparatuses, called "self-contained self-rescuers" (SCSRs) were designed to provide a one hour supply of oxygen which, theoretically, would allow an escaping miner to reach fresh air. A major effort in training therefore came to be focused on proficiency in using an SCSR and knowledge of the mine's escapeways.

Although escape skills have received much attention in the past 15 years, research has shown that miners receive little actual practice in survival techniques under realistic conditions (Vaught et al., 1990). Training tends to be didactic, delivered in the classroom, instead of heuristic hands-on instruction. As a consequence, miners who must escape a burning coal mine may have to move through smoke for the first time in their lives, use a breathing apparatus with which they are largely unfamiliar, and try to find their way out in escape routes that they have traveled infrequently, if at all. All those factors may add stress to an already stressful situation.

The stress response is a normal human reaction in which the body prepares to fight or to run when faced with a threatening situation. It is sometimes referred to as the "fight or flight response" and

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is regarded as a survival mechanism. Psychosocial (emotional) stressors may be described as environmental events in which the individual's interpretation is key to triggering the stress response. Regardless of the source of stress, there are definite physiological reactions such as dry mouth, sweaty palms, cessation of digestion, the movement of blood to the skeletal muscles, an increase in heart rate, temperature, respiration, an increase in visual acuity, and other bodily reactions (Kowalski, 1995). All these reactions prepare the body to fight or to run. Some symptoms may evoke additional anxiety. A pounding heart, sweaty palms and dry mouth may cause an individual to ask "What is the matter with me? What is happening to me?" causing further anxiety and reaction.

### Research Questions

It is important to note that psychosocial stressors do not *directly* cause the stress response. The *interpretation* the individual affords the stressor determines whether the stress response is initiated. The issue of *individual interpretation* is key when we look at controlling or mitigating the stress response. Are individuals who have had experience with a particular stressful situation more likely to interpret a potential stressor as more or less harmful? Can training impact the interpretation and thus the initiation of the stress response?

### Research Method

This study centered upon a mock evacuation from an underground mine. Realism was added to the exercise with the use of nontoxic theatrical smoke and training models of SCSRs. Small groups of miners were required to don their SCSRs, enter a smoke-filled area, and travel approximately 270 meters to a door through which they exited into fresh air. Individual subjects then provided self-reports of their experiences on questionnaires administered immediately upon the completion of their walk through smoke.

The evacuation exercise presented a number of potential sources of stress for the subjects. First, trainees had to don and wear SCSRs through the exercise. Although all these miners had donned this equipment in past training sessions, many never had worn the apparatus for more than a couple of minutes. Second, each person had to walk through theatrical smoke which reduced visibility to less than ½ meter. Most of the miners had little or no experience traveling through smoke. Another potential source of stress came from going through this experience with co-workers. These subjects would continue to see each other and work together after this study was completed. It is therefore likely that they did not want to appear inept or foolish in front of co-workers. Combinations of these elements produced stressful situations during this study.

The setup for this field experiment consisted of isolating an area of an underground mine so that ventilation within the area would be stopped. This was accomplished by erecting two seals

approximately 270 meters apart in a passageway. Each seal had a door through which subjects could pass. Three smoke generators were placed in the passageway between the seals. "Smoke" was produced until visibility was lowered to no more than ½ meter.

The SCSRs were placed on the smoke-free side of the first seal. Several observers were stationed on the smoke-free sides of the seals to monitor the SCSR donning portion of the experiment and observe miners' interactions. Another observer, serving as a safety check, walked through the "smoke" with the subjects. This safety person stayed within hearing distance of the miners, but well out of their sight. Small groups of six to nine miners went through the exercise together. During the exercise, they were allowed to assist and interact with each other if they wished. All the subjects completed the activity without observer intervention.

After they left the smoke area and removed their SCSRs trainees were asked to complete, anonymously, a one page questionnaire. Miners' responses on the confidential questionnaire provided demographic information and also data regarding their perceptions of the smoke evacuation experience. Seventy-four miners participated in the ten groups that made up the field experiment. The subjects were coal miners with an average of 19 years of underground mining experience. The average age of the group was 43. Twenty-seven percent of them had received some form of prior smoke training and 43% had experienced real smoke (of varying intensity) in their work setting. Thirty-seven percent of trainees had worn a breathing apparatus in smoke at some time in their mining career. When asked if they thought that "the smoke drill training was realistic," 97.3% responded that it was.

Four questions which directly addressed the issue of stress were included on the questionnaire. The miners were asked if they had experienced 1) physical or 2) emotional symptoms of stress; 3) if their reactions surprised them; and 4) if they thought that the topic of human response to stress should be part of mine emergency evacuation training. They were asked to respond by circling a number on a scale from 1 to 5 (1=Not at all, 3=Somewhat, and 5=Totally). Results of miners' responses are shown in figures 1 through 4. To simplify the figures, the scales are anchored with No, corresponding to the response *Not at all*, and Yes, which corresponds to the response *Totally*.

A detailed analysis shows that the responses provided to questions 1, 2, and 3 varied, based upon the miners' backgrounds. Those who had received prior smoke training, had encountered smoke underground, or had worn a breathing apparatus in smoke prior to the training, responded differently from those miners without such experiences. Extent of experience, however, seems unrelated to the answers to question 4, which asks whether human response to stress should be part of emergency evacuation training.

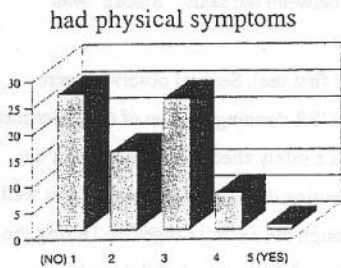


Figure 1: Question 1. I experienced physical symptoms of stress such as sweaty palms, increased or rapid heart beat.

Figure 2: Question 2. I experienced emotional symptoms of stress such as distress, fear, panic.

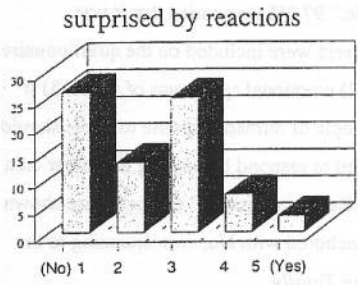
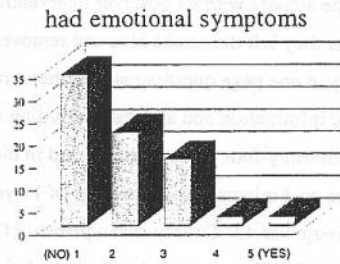
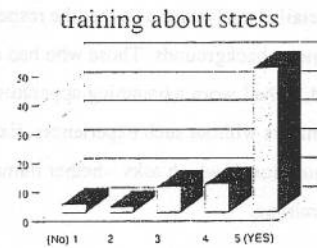


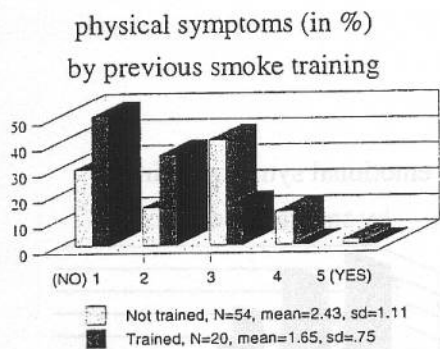
Figure 3: Question 3. My physical and/or emotional reactions surprised me.

Figure 4: Question 4. The topic of human response to stress should be part of emergency evacuation training.



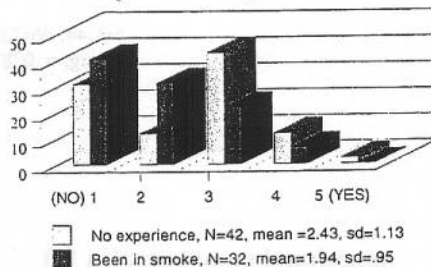
Figures 5, 6, and 7 show the data for questions 1, 2, and 3 grouped according to whether or not the subjects had reported past training and experience. The hypothesis tested was that miners with more experience would report fewer physical and emotional symptoms and would be less surprised at their reactions during the smoke drill. Experience was measured in three ways: smoke training, smoke experience and experience with apparatus. In all cases, miners with more experience reported fewer physical symptoms, less emotional stress, and were less surprised by their reactions. The statistical significance of the findings is reported based on one-tailed *t* tests.

Figure 5: Effect of Past Experience on Physical Symptoms



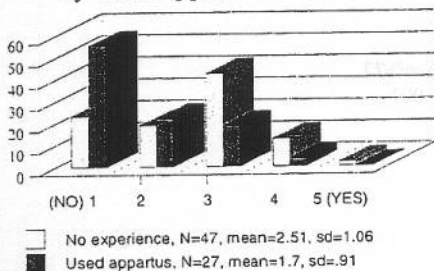
$t=3.45, df=50.73$   
 $sig. = .001$

physical symptoms (in %)  
by smoke experience



$t=1.98, df=72$   
 $sig. = .026$

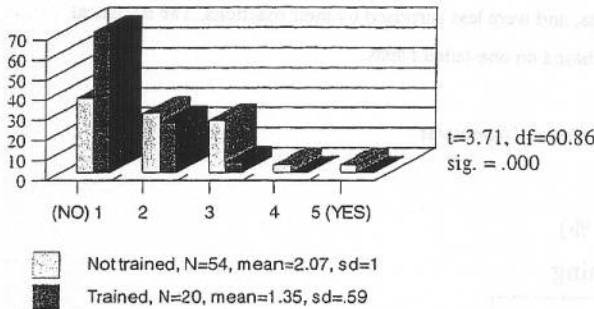
physical symptoms (in %)  
by worn apparatus in smoke



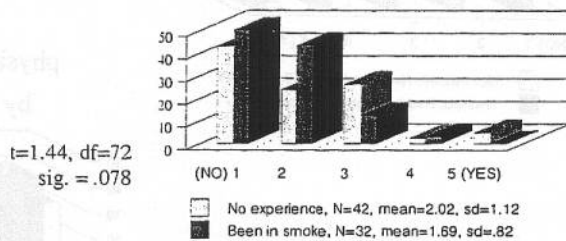
$t=3.31, df=72$   
 $sig. = .001$

Figure 6: Effect of Past Experience on Emotional Symptoms

emotional symptoms (in %)  
by previous smoke training



emotional symptoms (in %)  
by smoke experience



emotional symptoms (in %)  
by worn apparatus in smoke

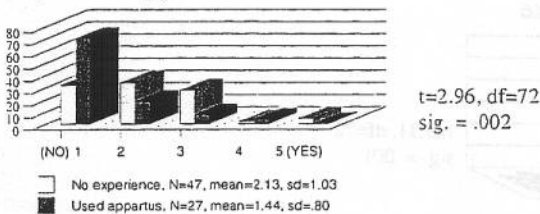
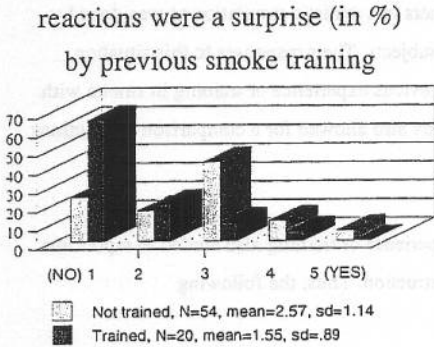
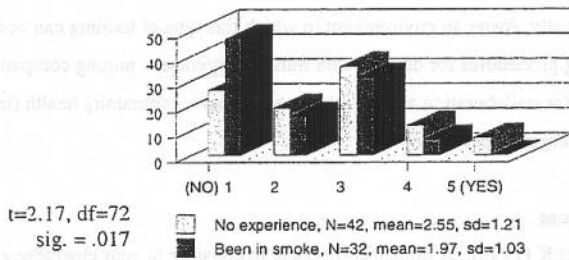


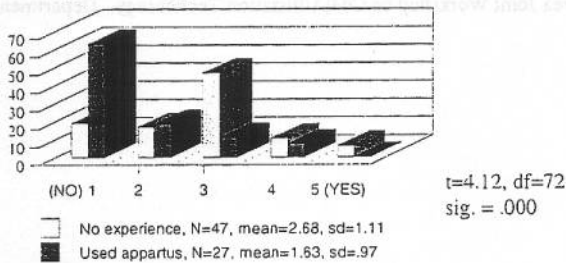
Figure 7: Effect of Previous Experience on Surprise to Reaction



reactions were a surprise (in %)  
by smoke experience



reactions were a surprise (in %)  
by worn apparatus in smoke



## Discussion

In an emergency situation such as escape under apparatus in smoke from an underground mine, the stress response is a normal reaction. Placing miners in a realistic simulation as was done by design in this study, created a stressful situation for these subjects. Their responses to this situation presented an opportunity to compare individuals having previous experience or training in smoke with those who had no previous experience or training. The study also allowed for a comparison of reactions to stress based upon previous experience or training.

The general finding that miners who had more experience or training also tended to report less stress during the exercise suggests the value of realistic instruction. Thus, the following recommendations are offered:

- Develop emergency escape simulation training as part of Annual Refresher Training in the U.S.
- In the training, include information about the human stress response for all mine workers and, especially, for mine rescue teams.

Additionally, foster an environment in which this type of training can occur. It is suggested that, in planning procedures for dealing with mine emergencies, mining companies develop relationships and arrange for collaboration among mine management, community health (including mental health), and local emergency personnel.

## References

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