DISTRESS ALERT SIGNALS FROM PERSONAL ALERT SAFETY SYSTEMS DEVICES DO NOT TRIGGER PHYSIOLOGICAL RESPONSES

EXECUTIVE LEADERSHIP

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ABSTRACT

Osceola County Emergency Services Department is in an urban and rural county with a diverse community that has experienced tremendous growth during the last 5 years, as well as an increase in both emergency and non-emergency incidents. The problem noted with the increase of incidents Osceola County has experienced, is that a number of firefighters, with no apparent sensory deficits do not respond immediately to the distress signal of the Personal Alert Safety Systems device when engaged in heavy fire suppression activities, search and rescue activities, or both. The purpose of this research project was to investigate internal conditions and their relationships, as well as the external forces and their impact on firefighter's immediate response to the activation of PASS device's distress alert signals.

This project employed evaluative and historical research methods to (a) determine if firefighters are able to distinguish the numerous distinct events and sounds as a human listener from busy fire ground ambience, (b) determine if firefighters' responses are becoming conditioned or are we shaping their behavior regarding the auditory stimuli of the distress alert tone from Personal Alert Safety Systems devices, (c) determine if physiological impairments associated with the firefighter's age affect stimuli reaching the auditory system, (d) determine some of the limitations and deficiencies of the Personal Alert Safety Systems devices, (e) determine what are some of the advantages of the Personal Alert Safety Systems devices, and (f) determine if polygraph apparatus that evaluates physiological biofeedback are useful for data acquisition of firefighters' responses to the distress tone of Personal Alert Safety Systems devices.

The procedure used involved a review of academic and trade journal publications, interviews, questionnaires, and a clinical study. A comparison of literature reviews of Personal Alerting Safety Systems devices, acoustic information, hearing impairments, conditioning stimulus, and stress related physiological responses was made. In addition, interviews and a questionnaire were used to obtain firefighters' and chief officers' perceptions of their response to the activation of the Personal Alert Safety Systems device which they have seen on the fire ground, heard on the fire ground, or both.

The major findings of this research were that firefighters, as well as non-firefighters do not have a physiological response to the distress signal from the Personal Alert Safety Systems device. Additionally, the research indicated that firefighters appear to be conditioned to perceive the distress tone as a false activation and not that of urgency, as well as to not respond immediately to the distress signal unless other visual or auditory information is available. The recommendation resulting from this research indicated a need for computer-based physiology feedback to determine which Personal Alert Safety Systems device cause a response in order for firefighters to respond immediately to the distress signal of jeopardized firefighters. However, it was also noted that Osceola County, as well as many of the municipalities in Central Florida, do not have the physical budget to purchase computer-based assessment to determine which type of distress alerting signal causes a physiological response when heard. Therefore, it was recommended that another agency, such as the National Fire Academy or the National Fire Protection Association (NFPA), do further research using computer-based assessment to evaluate the physiological response of firefighters to the distress signal of Personal Alert Safety Systems devices.

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INTRODUCTION

"Almost every veteran firefighter knows what it is like to become lost or disoriented in the smoke-filled rooms of a burning building" (Wojcik and Saly, 1980, May, p. 61). It has been espoused that many firefighter deaths can be attributed to being disoriented and overcome by smoke-filled hostile environments (National Fire Service Organization, 1995, December; Hollins, 2000, March). In 1979, Robert Grant, President of the National Fire Protection Association (NFPA) "insisted that many of the 162 firefighter deaths who died in the line of duty… might have been saved, but because of distance, disorientation, or injury, they were unable to alert others that they were in trouble" (Wojcik and Saly, 1980, May, p. 61). As a result of Grant's statement regarding firefighter deaths being attributed to not being able to alert others when they were in trouble, many fire departments, such as the City of Los Angeles (CA) Fire Department (Wojcik and Saly, 1980, May) and the City of Mesa (AZ) Fire Department, began purchasing distress-alerting devices. These distress-alerting devices were designed to sound continuous audible distress tones of about 90 decibels (dBs) in order to alert others that they were in trouble (Rubin and Rio, 1986, November).

"In 1980 the National Fire Protection Association's [NFPA] Technical Committee on Protective Equipment for Firefighters responded to requests from the fire service to develop requirements for a device that would signal for aid in the event that a firefighter became incapacitated on the scene of an emergency" (United States Fire Administration Federal Emergency Management Agency, 1996, p.33). These requirements are known as NFPA 1982, Personal Alert Safety Systems (PASS) for Firefighters, and the standard suggests that every self-contained breathing apparatus be outfitted with a PASS. As a result of this standard a "…great majority of firefighters are wearing personal alert safety system [PASS] devices when they enter burning buildings" (Routley, Bush and Stern, 1996, July, p. 134). However, the National Fire Data Center United States Fire Administration Federal Emergency Management Agency (2000, July) wrote, "In 1999, 16 firefighters died in situations where the provision and use of personal protective clothing [equipment] possibly could have prevented their deaths" (p. 42).

One example of such a death involved the lack of the use of personal protective equipment. On May 30, 1999, in the District of Columbia there were two firefighters overcome by the progression of fire in a residential structure. One firefighter had a manually activated PASS device, which was found in the off position and the other firefighter that had been trapped was rescued. He had an automatically activated PASS device that alarmed. However, both firefighters died, even though the one firefighter was removed more rapidly because of the automatically activated PASS device that aided in his discovery.

Even though personnel do not always activate their PASS devices, an analysis of these and other firefighters deaths indicates that there is a gradual trend towards fewer firefighter fatalities because of the personal protective clothing and personal alerting distress devices. This downward trend can be accredited to NFPA 1982 and the mandatory use of Personal Alert Safety Systems devices that many fire departments have established for any firefighter engaged in suppression or rescue activities. However, the effectiveness of the personal alerting device's "…sounds are by no means ideal in terms of perceived urgency" (Smith and Withington, 2000, January, p. 27). Distress alert signals which are not perceived as urgency have been documented numerous times by the local news media as firefighters are shown still engaged in suppression activity with the sound of the distress alert signal from PASS devices sounding in the background. One such example was May 1, 2001, 5:30 PM, when Channel 11 News, WBAL, Baltimore, Maryland, reported a fire at Mike Tyson's Baltimore home with firefighters' PASS devises' distress alert tone sounding while engaged in suppression activities. On June 3, 2001, 11:00 PM, Channel 9 Eye Witness News, WFTV, Orlando, Florida, reported a residential structure fire with a PASS device's distress alert signal sounding during the entire news briefing of the fire. Another example was June 11, 2001, 6:30AM. Channel 9 Eye Witness News, WFTV, Orlando, Florida, reported a residential structure fire started by a candle. The on scene reporter talked over the sound of a PASS device's distress alert signal while firefighters were shown doing an overhaul of the burned out structure and picking up hose lines. On June 20, 2001, 2:09AM, firefighters from the City of St. Cloud (FL) Fire Department and Osceola County Emergency Service aggressively mitigated a residential structure fire where five children and one adult died a tragic death. A personal observation was that after the fire had been knocked down and during the primary and secondary search for the missing children and the adult, numerous PASS devices were activating. However, the focus was on the search for victims and not the distress alert signal.

The problem that served as a catalyst for this research was that the Osceola County Emergency Services Department, as well as many other Fire Departments, have begun to experience a number of firefighters with no apparent sensory or hearing deficits not responding immediately to the activation of the distress alert signals of the Personal Alert Safety Systems device while firefighters are engaged in heavy fire suppression activities, search and rescue activities, or both. Because there are no apparent sensory or hearing deficits in the firefighters, and no existing physiological tests to indicate that auditory stimuli of the distress alert tone is perceptually acceptable, this condition has been hypothesized to be the result of firefighters' complacency to the majority of distinct auditory events on a fire ground and the number of false activations of PASS devices through classical conditioning, operant conditioning, or both. However, some may be of the opinion that it is related to physiological impairments associated with the shift in age from a younger population to that of an older firefighter population. Additionally, some may even believe that the busy fire ground ambience blocks the distress signal when mixed with other fire ground activities and noises. Nonetheless, this is a "crucial deficiency for such a potentially life-saving piece of equipment" (Smith and Withington, 2000, January, p. 27).

The purpose of this research, by means of literature review, questionnaires, interviews, and clinical studies, was to evaluate both internal conditions and their relationships, and the external forces and their impact on firefighters' immediate response to the activation of PASS device's distress alert signals. Evaluative and historical research methods were employed to answer the following questions:

Research Questions

1. Are firefighters able to distinguish the numerous distinct events and sounds as a human listener from busy fire ground ambience?

2. Are firefighter's responses becoming conditioned or are we shaping their behavior regarding the auditory stimuli of the distress alert tone from Personal Alert Safety Systems devices?

3. Do physiological impairments associated with the firefighters age affect stimuli reaching the auditory system?

4. What are some of the limitations and deficiencies of the Personal Alert Safety Systems devices?

5. What are some of the advantages of the Personal Alert Safety Systems devices?

6. Is a polygraph apparatus that evaluates physiological biofeedback useful for data acquisition of firefighters' responses to the distress tone of Personal Alert Safety System devices?

BACKGROUND AND SIGNIFICANCE

Osceola County Emergency Services Department is located in Osceola County, Florida, and is made up of the Fire Rescue Division and the Emergency Management Division. The Fire Rescue Division is considered a combination fire department that provides first response Basic Life Support and Advanced Life Support, as well as fire protection to an area encompassing 1,506 square miles. However, by definition, the Fire Rescue Division is not a combination department because there are nine separate volunteer departments along with the career stations that make up the fire service.

Osceola County consists of cattle and farmlands, low to high-density residential areas, rural and residential interface regions, medium to high-density commercial, medium level industrial, and medium to high-speed intrastate highway systems. This once rural county has experienced tremendous growth in the last 5 years because of the continuous encroachment of commercial and industrial businesses that support the vibrant economic environment surrounding Walt Disney World, which brings 7.5 million visitors to Osceola County and Central Florida annually. Osceola County is the fourth fastest growing county in Florida, as well as the sixth largest county in Florida.

This tremendous development and economical growth within the county has increased the population density, as well as the need for emergency services throughout the different communities in Osceola County. Nine different volunteer fire districts provide first response to many urban and rural communities in Osceola County, with a career fire department that provides first response and Advanced Life Support to the areas surrounding Walt Disney World and the tourist areas.

The problem addressed in this research paper relates to the National Fire Academy's *Executive Leadership* course, which discussed specific tools and techniques to use in influencing others. The course discussed the theory of influencing which involves the analysis of the problem and its cause, as well as involving four process activities, three styles, and a series of steps for designing a plan to influence. During the presentation and discussion of Unit 12: Influencing Styles, the focus was on continuously searching for ways that executive fire officers can improve performance by recognizing internal conditions and their relationship to persuasion, common vision, and participation and trust, as well as recognizing external forces and their impact on the influencing styles. However, first a review of the relevant facts and an analysis of why firefighters with no apparent sensory or hearing deficits, are not responding immediately to the activation of the Personal Alerting Safety Systems devices while firefighters are engaged in heavy suppression activities, search and rescue, or both must be completed before designing a plan to influence in order to educate others. Therefore, a review of case studies in firefighter fatalities that possibly resulted from not activating the Personal Alert Safety Systems device or the failure of the device will need to be conducted, as well as whether or not the distress signal is perceived as urgency. Thus, the emphasis of this research will be to evaluate the significance of physiological responses to the distress signal, as well as whether or not distinct sounds from fire ground ambience can be perceived through a subjective listening test.

LITERATURE REVIEW

The literature review was performed to analyze the perception of numerous distinct sounds by firefighters as human listeners, in both younger and older populations, regarding busy fire ground environments, as well as if the false activation of the Personal Alert Safety Systems (PASS) devices was conditioning or shaping firefighters' behavior of not responding immediately while engaged in heavy fire suppression activities. The literature reviewed testing protocols to measure performance criteria for PASS devices, and physiological impairments associated with hearing and aging. The literature review involved a search of trade journals, textbooks, the Internet, and interviews. The following literature review provides additional support to parallel and correlate the research proposed. This section discusses:

1. Personal Alerting Safety Systems Devices
2. Acoustic Information
3. Hearing Impairments
4. Classically Conditioned Stimulus
5. Shaping Behavior
6. Stress Related Physiological Responses

Personal Alerting Safety Systems Devices

Wojcik and Saly (1980, May) wrote that after a warehouse fire, firefighters of the Los Angeles City Fire Department reported that one of their members "would probably have been saved if he had been equipped with a personal audio alarm. They contended that it would have immediately pinpointed his location, allowing firefighters who were within a few feet…" (p.62) to have saved his life. Wojcik and Saly (1980, May) suggested that as a result of the tragic loss of one of their firefighters, Los Angeles City union members asked that it be mandatory for all firefighters to be issued a personal alerting device. However, the Department "turned down the request, saying that they would not order the use of personal alarm devices until a thorough test had been run to assure effectiveness and reliability" (p. 62). Contravene to the Department's position, firefighters brought the case to the California Occupational Safety and Health Administration (Cal/OSHA). Wojcik and Saly (1980, May) wrote that as the outcome of Cal/OSHA's findings Los Angeles City Fire Department contacted the United States Fire Administration for a grant to field and lab test the Personal Alarm Locator (PAL).

Rubin and Rio (1986, November) wrote as a consequence of the comprehensive testing the "research indicates that such an alarm system could have helped to prevent tragic incidents involving the loss of firefighter lives" (p. 16). "Responding to the request from the fire service to develop requirements for a device that would signal for aid in the event that a firefighter became incapacitated on the scene of an emergency" (United States Fire Administration Federal Emergency Management Agency, 1996, p.33) the National Fire Protection Association's (NFPA) Technical Committee on Protective Equipment for Firefighters established NFPA 1982 - *Standard on Personal Alert Safety Systems for Firefighters*.

The NFPA 1982 standard specifies operations, as well as testing criteria for Personal Alerting Safety Systems (PASS) devices. The United States Fire Administration Federal Emergency Management Agency (1996) wrote:

> These devices must be able to function in hazardous environments and are required to be intrinsically safe. They have three modes of operation: off, manual, and automatic. To prevent accidentally deactivating the device, two manual actions must be required to switch the unit from automatic to off. PASS devices have three tones. The first is an operational signal to inform the operator that the device is functioning properly. Another is a pre-alert signal that goes off ten seconds before the alert signal and can be disabled by the firefighters moving. Finally, there is the alert signal which goes off either manually or when the device has not sensed motion in 30 seconds (p. 33).

Even with the NFPA 1982 Standard, many factors with personal alerting devices have been identified in several line of duty investigations. The United States Fire Administration Federal Emergency Management Agency (1996) wrote:

> …personnel do not always activate their PASS devices at the scenes of emergencies. In some firefighter fatality investigations it has been discovered that firefighters killed during fire suppression operations failed to turn on their PASS devices. This phenomenon can be attributed to many reasons, however, regardless of the reasons, this presents a serious dilemma (p. 33).

Along with that serious dilemma several authors, such as Routley, Bush and Stern (1996, July), Rubin and Rio (1986, November) and Smith and Withington (2000, January) noted other problems with the PASS devices. Rubin and Rio (1986, November) wrote, "the noise bouncing off of walls, ceilings, and floors seemed to confuse the searchers" (p. 16). Smith and Withington (2000, January) paralleled Rubin and Rio (1986, November) suggesting there was a serious quandary in how the alerting tone is perceived and, more importantly, the distress signals are impossible to locate. Routley, Bush and Stern (1996, July) noted similar problems with the PASS devices and added, "A tremendous amount of money has been spent on PASS devices that false alarm so often that most of them are not turned on" (p. 134). Routley, Bush and Stern (1996, July) suggested, "A PASS that is less prone to false alarms and is automatically activated by the air pressure of self-contained breathing apparatus [SCBA] appears to be the best answer" (p. 134).

Campbell (2001, April 8) and Burris (2000, July) espoused that the National Institute of Standards and Technology Building and Fire Research Laboratory are currently testing Personal Alert Safety Systems devices to improve precision. Campbell (2001, April 8) wrote evaluations would be performed in the laboratory, as well as a series of controlled burns to study the "elimination of alarms, improved accuracy, linking to Global Positioning Systems…" (p. 1). Page (May, 2001) paralleled Campbell (2001, April 8) indicating that the National Institute of Standards and Technology (NIST) has embarked on examining specific enhancements to the Personal Alert Safety Systems devices which includes the "elimination of false alarms, improved accuracy, links to the Global Positioning Systems…" (p. 24). Campbell (2001, April 8) and Page (2001, May) espoused that sophisticated examinations, as well as physiological testing, is being conducted to determine the performance of the Personal Alert Safety Systems devices under live fire conditions in a series of controlled town house and apartment fires, as well as laboratory trials that expose the devices in ovens. Page (2001, May) wrote, "the NIST tests aren't attempting to determine which model outperforms another, rather, they're evaluating overall performance of all devices" (p. 28).

Acoustic Information

Ellis (1996) wrote, "In real world environments there may be any number of contributors to the total sound scene; how can we even define the basic elements, the analogs of the simple sine tones and bursts of white noise" (p. 9). Alford (2001, April 31) espoused these basic elements or environmental sounds are analyzed and interpreted by the brain and then mapped according to their frequency.

Warren (1993), Ellis (1996), and Norris (2001, May 28) researched the listener's perception of distinct events in ambient sounds in busy environments and found that many times the listener cannot interpret the combination of difficult sounds. In addition, Ellis' (1996) research suggests that listeners are able to replace these difficult or impossible to recover signals found in noisy environments by making estimates of the missing sounds. Ellis (1996) wrote, "The most extreme example of this kind of phenomenon is the auditory induction of…missing information where entire syllables are replaced by noise without the listener's conscious awareness" (p. 48). Ellis (1996) also suggested that in almost every listening task similar filling-in occurs. Another psychoacoustics phenomena that Ellis (1996) suggests is where a "… tone alternating with a burst of noise will, under suitable conditions, be perceived as continuing through the noise, in spite of the fact that the sound stimulus was not constructed that way" (p. 49). Ellis (1996) espoused Warren (1993) suggesting that this is an example of retroactive modification resulting from the interpretation of a sound. Ellis (1996) conducted research using short segments of noise with the same power spectral density but different bandwidths, which are alternated. Ellis (1996) wrote, "that such a particular sound pattern will have an acute influence on the auditory system to interpret any closely-following similar sounds as repetitions of that pattern" (p.106). Ellis (1996) and Norris (2001, May 28) used subject's perception and computer modeling of the same real world complex sound mixtures from city streets to identify and describe how human listeners organize sound.

Hearing Impairments

Patterson (2001, May) wrote, "hearing impairment refers to limitation of function as measured by raised hearing threshold, measured as decibels of hearing loss [dB HL] relative to the hearing of a normal population, at specific frequencies" (p. 1). Bonk (2001, June 4) wrote, "Hearing impairments are due to many different causes including pre-natal and post-natal problems, accident, illness, or the aging process" (p. 1). Patterson (2001, May) suggested that age-related hearing loss is a common phenomenon which is known as presbycusis which causes difficulties in sensing higher frequencies above 1000 Hz. In comparison, Campbell (1990) wrote that healthy young humans could hear sounds in the range of 40 to 20,000 Hz. However, Alford (2001, April 31) and Vernick's (1993) research slightly differs from Campbell's (1990) research by suggesting that human hearing is capable of responding to a range of frequencies between 20 to 20,000 cycles per second. Vernick (1993) also suggested that human hearing is sensitive to different sounds at different levels of intensities and when the human listener hears all these different sounds at once it is referred to as white noise. Vernick (1993) suggested that hearing is acute during childhood and then the ability to hear as acutely begins to diminish after age 10. Vernick (1993) espoused human listeners can hear sounds at 0 decibel level (dB) which is the faintest sound heard (the threshold of hearing).

Classical Conditioned Stimulus

Rubin and McNeil (1981) wrote, "classical conditioning plays an important role in learning emotional responses…" (p. 139). Baron (1995) added that classical conditioning elicits a particular response and, in most instances, gradually acquires the elicited response. Rubin and McNeil (1981) and Baron (1995) suggested the elicited response is the result of pairing an emotion with a positive or negative response that serves as conditioned stimuli. Additionally, Rubin and McNeil (1981) suggest in order for this classically conditioned stimulus to continue, the stimulus needs to be repeated, as well as the pairing of the response, either unconditioned stimulus or conditioned stimulus. Baron (1995) parallels Rubin and McNeil (1981) adding that learning this type of response is quite common and seems to play a role in such varied reactions. Rubin and McNeil (1981) wrote, "If the conditioned stimulus is repeatedly presented without the unconditioned stimulus, the response becomes weaker--less vigorous and less likely to occur" (p. 141). Rubin and McNeil (1981) compared this type of response to Pavlov's experiment where he would ring the bell as the conditioned stimulus over and over without giving the food, the unconditioned stimulus, and then the dogs salivated less and less. Rubin and McNeil (1981) wrote, "such weakening of a learned response is called extinction" (p. 141). Rubin and McNeil (1981) also, suggested that extinction involves a gradual decrease in the strength of the response.

However, the response can be activated again even though it is unlearned. Rubin and McNeil (1981) stated that Pavlov called this phenomenon spontaneous recovery. Baron (1995) referred to this same response as reconditioning. Baron (1995) stated that the phenomenon spontaneous recovery is when the conditioned stimulus is interrupted for a period of time without any type of stimulus, then the reappearance of the reaction to the stimulus is spontaneous although in a weakened form.

Baron (1995) described animal research where the conditioned response rapidly increases when the intensity of either the conditioned or unconditioned stimulus is enhanced. Baron (1995) also espoused that it is not necessarily the unadulterated intensity of a stimulus that is most important to the conditioning process, but it is the strength of the conditioned response relative to other background stimuli. Baron (1995) described a study conducted by L. J. Kamin, *Temporal and Intensity Characteristics of the Conditioned Stimulus*, 1965, where laboratory rats were conditioned to 80 decibels of white noise:

> The laboratory rats were then divided into groups that received varying reductions in the noise level as the conditioned stimulus. The reduction in noise was always followed by an unconditioned stimulus, an electrical shock. The rats receiving the largest reduction in noise level as a conditioned stimulus--which interestingly was also the least intense level of noise in absolute terms--demonstrated the greatest evidence of conditioning (p. 163).

Baron (1995) suggested that the conditioning effect can become familiar, such as day-to-day experiences or background noise that does not usually present or represent anything unusual. Baron (1995) wrote, "We learn that these stimuli are largely irrelevant, which makes future conditioning of them difficult" (p. 163).

Baron (1995) espoused that there are cognitive perspectives on classical conditioning and one of those cognitive perspectives is a phenomenon referred to as blocking. Blocking is where conditioning to one stimulus may be prevented by previous conditioning to a different stimulus. Baron (1995) used the illustration of a dog initially being conditioned to a tone:

> After repeated pairing with presentation of meat powder, the tone becomes a conditioned stimulus, capable of causing the dog to salivate. Then a second stimulus, a light, is added to the situation. It too occurs just before the presentation of food. If classical conditioning occurs in an automatic manner, simply as a result of repeated pairing of a conditioned stimulus with an unconditioned stimulus, then the light too should become a conditioned stimulus (p. 168).

Baron (1995) stated the light elicited salivation when presented alone indicating the blocking of the first stimulus, the food.

Shaping Behavior

Feist (1994) described a more comprehensive approach to conditioning recognized by B.F. Skinner that was published in a 1953 article *Science and Human Behavior*, which was identified as operant conditioning or shaping behavior. Wade and Tavris (1994) espoused Feist (1994) adding that "classical and operant conditioning often occur in the same situation" (p. 209). Wade and Tavris (1994) and Baron (1995) suggested that operant conditioning is based on learning through reinforcement based on consequences. Feist (1994) and Wade and Tavris (1994) suggested operant conditioning is the immediate reinforcement of a specific response to any environmental consequence which can be more or less depending on the consequence. Baron (1995) supported Feist (1994) and Wade and Tavris (1994) adding the probability that a specific response will occur based on the consequences that follows either a positive reinforcement or negative reinforcement. Stewart (2001, May 19) exposed Feist (1994), Baron (1995) and Feldman (1999) stating "reinforcement is any consequence that makes a behavior more common and punishment is any consequence that makes a behavior less common" (p. 1). Feist (1994) wrote, "operant conditioning changes the frequency of a response or the probability that a response will occur. The reinforcement does not cause the behavior, but increases the likelihood that it will be repeated" (p. 355). Feist (1994) also stated that operant conditioning emitted behavior, whereas, other conditioning, such as classical conditioning elicited behavior. Feist (1994) suggested that emitted responses do not previously exist inside the respondent and simply appear because of shaping and successive approximation. Feist (1994) described successive approximation as gradually shaping the final behavior. Feist (1994) and Balkenius (2001, May 19) suggested that because shaping behavior is a continuous process that we move slightly beyond the previously reinforced response and the new minimum standard becomes the shaped behavior that is tolerated by the environment. Feist (1994) wrote, "behavior always takes place in some environment, and the environment has a selective role in shaping and maintaining behavior" (p. 356).

Stress Related Physiological Responses

According to the American Polygraph Association (2001, May 25) "over 250 studies have been conducted on the accuracy of polygraph testing during the past 25 years" (p. 1). American Polygraph Association (2001, May 25) suggests that the accuracy of decisions based on polygraph readings is around 95 percent. Truth or Lie Polygraph Examination Agency (2001, May 29) and Polygraph Investigations (2001, May 29) substantiated the American Polygraph Association's (2001, May 25) findings, adding that one of the problems and differences between the statistics is the way that figures are calculated. Truth or Lie Polygraph Examination Agency (2001, May 29) suggested that critics of the polygraph technique would include inconclusive test results, which would distort the accuracy rate and lower the percentage of accuracy. Truth or Lie Polygraph Examination Agency (2001, May 29) listed the most frequent errors during a polygraph that could lead to the results being inconclusive:

1. Misinterpretation of the data on the charts,

2. Lack of training and experience of the polygraph examiner,

3. Counter-measures from the examinee

4. A lack of quality control review,

5. Equipment malfunction,

6. Failure to properly prepare the examinee for the examination,

7. Poorly worded test questions,

8. Improper assessment of the examinee's emotional and physical condition, and

9. Improper use of testing techniques (p. 1).

American Polygraph Association (2001, May 25) suggested that when a person "guilty of a particular event is being tested, he or she expresses some 'fear of detection', which causes them to respond excessively to questions relating directly to that event" (p.1). American Polygraph Association (2001, May 25) suggested that the anxieties and apprehensions recorded on the polygraph do not indicate directly if a person is lying; however, records "very accurately, changes which take place inside the body during stress…" (p. 1).

Allenson, Zanta and Gedney, (2001, June 21) suggested a polygraph test consisted of three different phases: the pre-test interview, the test and the post-test which included the responses of the questions on polygraph charts and an analysis of these charts. American Polygraph Association (2001, May 25) espoused Allenson, Zanta and Gedney (2001, June 21) adding the average polygraph test usually lasts between one and two hours and suggested that the longest part of the test was the pre-test interview, taking 30 to 45 minutes.

American Polygraph Association (2001, May 25) wrote:

> The polygraph consists of three or more components: the pneumograph which records respiration and movement, the galvanograph which records Galvanic Skin Response and changes in skin resistance, and the cardiosphygmograph which records relative blood pressure and pulse rate. Once the pre-test interview has been completed, the polygraph examiner will place five attachments on the subject: two rubber pneumograph tubes across the upper chest and abdomen, two metal fingerplates - one on the ring and one on the index finger - and a blood pressure cuff around the upper arm. During the test procedure, the examiner will ask the reviewed questions two or three times and run a minimum of two to three separate tests (p. 2).

Frazier (personal communication, June 20, 2001) espoused that the polygraph could be used to measure internal and external stressors that result from emotional, and physical responses to the environment, such as auditory stimulus from fire ground noises. Frazier (personal communication, June 20, 2001) stated that the physiological events in response to the auditory stimulus could be measured using the polygraph when subjects recognize danger as a previous condition behavior. Frazier (personal communication, June 20, 2001) espoused that danger will automatically trigger physiological responses that will be indicated through the graphical output on the polygraph.

Summary

There are a number of studies and published literatures that focuses on clinical applications, and technology assessment, as well as physiological impairments associated with hearing loss. Additionally, there are several studies and published literature on Personal Alert Safety Systems devices being field-tested using physiological tests to evaluate over all performance of the devices. However, none of these publications or academic literature suggested that Personal Alert Safety Systems devices conditioned firefighters who have no apparent hearing deficits, not to respond to the urgency of the distress tone. Also, none of these publications or academic literature reviews suggests using clinical applications of physiological biofeedback assessment as part of their physiological tests to measure if the distress tone is perceived as urgency. One assumption that could be hypothesized is the lack of research in the area of firefighter's response to the distress tone. Nonetheless, the literature review provided enough background to build basis for further research on how the distress signal is perceived.

Before any solutions can be rendered, the next logical step is to survey firefighters and chief officers to determine their perspectives on Personal Alert Safety Systems devices, their misconception regarding false activations, or both. In addition, there needs to be an assessment using biofeedback quantitative measures to evaluate firefighters with no apparent hearing deficits not responding to the distress tone.

Once completed, this paper will give other chief officers and firefighters at Osceola County Emergency Services' Fire Rescue Division insight in physiological response to the distress alert tone from the Personal Alert Safety Systems device. It will also provide the direction in which to start the groundwork for future research.

PROCEDURES

The research procedure used in preparing this paper included a literature review, questionnaires, interviews, research questions, and involved clinical studies. This research explored whether or not the distress alert signal is perceived as urgency, as well as if firefighters have been conditioned not to immediately respond when the distress tone sounds because of believing it is just another false activation, and used physiological biofeedback assessment to prove or disprove this assumption. In addition, this paper explored whether or not physiological impairments associated with age impaired the hearing because of ambient background noise on fire grounds and if firefighters are able to distinguish the multiple mixture of fire ground noises if they are separated out without any background noise.

Definition of Terms

Abdominal Pneumographs are the physiological events measured by the respiration rate during a polygraph.

Computational modeling involves computer processing of acoustic data for the purpose of symbolic representations reflecting the perceived sound structure that enters a human listener's auditory system.

Classical conditioning is learning through the relationship of an unconditioned stimulus and unconditioned response paired with a new conditioning stimulus to elicit an old response.

Distress alert signal is the tone emitted from the activation of the Personal Alert Safety Systems device.

Extinction is when the conditioned stimulus reverts to being a neutral stimulus.

Galvanic Skin Response (GSR) is the basal resistance of the skin during a polygraph.

Galvanograph is the graphic output of the skin resistance during a polygraph.

Operant conditioning is learning as a result of a consequence.

Orienting reflex is the large response to the first question, or sound in this study, where physiological changes occur upon the stress during a polygraph.

Photoelectric Pulse Plethysmograph (PLE) is the physiological events heart rate which is measured during a polygraph.

Physiological challenges or changes are the body's stresses that are indicated in changes in respiration rate, perspiration, heart rate, and blood pressure. The term physiological challenges are interchanged with physiological events and physiological responses. All these terms have the same meaning.

Pneumograph records respiration and movement during a polygraph.

Polygraph Test is a method used to measure stress related physiological changes to detect untrue statements.

Presbycusis is the most common hearing problem in elderly people. The hearing loss is normally in those over the age of 50 and is linked to changes in the inner ear.

Sensorineural is the damage of parts of the inner ear or auditory nerve. The degree of hearing loss can vary.

Sine tone is the ability to establish a relative order of pitch when two pure tones of the same intensity are presented one after another (Roederer, 1973).

Spontaneous recovery is the extinguished conditioned response suddenly reappearing in response to a neutral stimulus after a period of non-exposure to the stimulus.

White noise is multiple tones or sounds being heard at the same time.

RESEARCH METHODOLOGY

Literature Review

The research was historical research in that a literature review of academic publications was conducted to understand auditory stimulus, and classical and operant conditioning. In addition, the literature review examined the testing procedures for Personal Alert Safety Systems devices and what type of computer-based assessment could be utilized to determine the physiological biofeedback responses to the distress alert signal that is omitted from the activation of the Personal Alert Safety Systems device. The historical research was initiated at the National Fire Academy Learning Resource Center, and continued with the academic publications at the University of Central Florida library in Orlando, Florida. An additional literature review was conducted on the Internet, using search engines, to explore Personal Alert Safety Systems, and classical and operant conditioning, and hearing impairments.

The literature review targeted academic research publications and trade journals that explored the physiological impairments associated with hearing and auditory stimulus in busy environments. The literature review also examined current clinical applications and assessment methods to determine the reliability and validity of using polygraph apparatus to measure various physiological events.

Interview

A personal interview was conducted with William "Bill" Frazier, Associated Polygraph, Inc., 140 N. Orlando Avenue, Winter Park, Florida. The purpose of the interview was to gain background knowledge and significant information on polygraph test to measure physiological changes in response to auditory stimulus from the distress signal of Personal Alert Safety Systems devices. The personal communication is included in the Literature Review section of this research paper.

Instrumentation

The instrument used in this research consisted of a cover letter (Appendix A), a demographic sheet (Appendix B) and a two-part questionnaire. The cover letter explained the purpose of this research and how the results of the survey would be utilized. It encourages cooperation and confidentiality and offered a copy of the summary results if desired.

The survey questionnaire appears in its final form in Appendix C. The questionnaire was administered to firefighters and chief officers of Osceola County Emergency Services Department and the nine volunteer fire districts in Osceola County, Florida. The firefighters and chief officers were given an explanation as to why the questionnaire was being presented, and each firefighter and chief officer was directed to complete the questionnaire as described in the directions at the top of each part of the questionnaire.

Upon completion, the surveys were collected and put in an envelope. The data would be analyzed once the target group was surveyed. No firefighter or chief officer was permitted to take the questionnaire from the survey room, nor were they permitted to fill it out later and return it to this author.

Questionnaire Procedure

Part I of the questionnaire requested that each respondent check his or her response to the activation of Personal Alert Safety Systems devices which they have seen on the fire ground, heard on the fire ground, or both.

Part II of the questionnaire requested that each respondent check the type of Personal Alert Safety Systems that they were currently using, as well as whether or not the respondents activated the device when entering hazardous environments.

After each respondent completed his or her survey, they were thanked for his or her time and participation.

Clinical Study Test Procedures

The subjective listening clinical study focused on the clinical applications and efficiency of the subject's perception of fire ground complex sound mixtures and his or her ability to distinguish the distinct fire ground sounds. The clinical study will investigate the subject's perception of distinct sounds mixed with general background noise from a fire ground in five to ten second fragments.

The physiological response clinical study used the multiple mixture of fire ground sounds with background noise, as well as distinct fire ground sounds that were separated as individual sounds without any background noise. William B. Frazier, Associated Polygraph, Inc., 140 N. Orlando Avenue, Winter Park, Florida 32789, conducted the stress related physiological clinical study at Osceola County Public Safety Complex, 320 N. Beaumont, Kissimmee, FL 34741. The purpose of the clinical study was to determine the following:

1) If subjects could distinguish distinct sounds from a mixture of fire ground ambience in both the subjective and physiological biofeedback test.

2) If subjects are perceptible to individual distinct sounds in the physiological biofeedback test.

3) The stress related physiological changes associated to individual distinct fire ground sounds, more importantly the distress tone of the Personal Alert Safety Systems device.

Test Subjects

The test subjects were four healthy, male and female firefighters, and four healthy male and female non-firefighters from moderate to excellent physical fitness with no apparent hearing impairments. The demographics of the subjects can be found in Appendix F.

Test Equipment

The Stuelting Emotional Stress Monitor was utilized in this clinical study. The monitor records and measures respiration and movement, Galvanic Skin Response (GSR) and changes in skin resistance, blood pressure, and photoelectric pulse plethysmograph.

Test Procedure

The first procedure was using stress related physiological biofeedback to quantify any reactions to fire ground ambience and then to the individual distinct sounds from the fire ground by measuring changes in amplitude and frequency. The peak amplitudes and the changes in frequency of the recorded responses represented the subject's physiological patterns or reactions to the sounds. As each sound is played, the times will be recorded. For instance, if sound # 1 was at 15 seconds, sound # 2 was at 30 seconds, and sound # 3 was at 60 seconds, record the sounds for each of these time points. After each distinct sound there was 15 seconds of silence to allow the subjects to achieve a state of relaxation before the next sound. A larger reaction in the amplitudes will indicate the subject's physiological response to the sound. During the procedure notations will be made regarding movements or test environment changes as these may be producing a reaction unrelated to the sound. Each of the subjects was asked to remain as still as possible and listen to the eight (8) individual distinct sounds listed below:

1. Fire ground ambience of heavy fire inside a structure and the operation changing to a defensive mode with Command requesting for a PAR (personal accountability report) and the pre-alert sounds of a PASS device.
2. Engine noise from a fire apparatus changing pitch as the RPM increases because of a pressure change.
3. Engine noise from a positive pressure fan stalling and then being re-cranked.
4. An anxious mother stating her baby was still inside the structure.
5. The pre-alert tone of a PASS device.
6. Command's acknowledgement of heavy fire on Side 3.

7. The activation of a PASS device from a distance.

8. The activation of a distress tone from a PASS device up close.

The second procedure was a recording of fire ground ambience with the above 8 distinct sounds mixed into the recording with background noise from the scene (visual representation of each of the waveforms using Microsoft Audio View can be found in Appendix O). The subjects, as human listeners, were asked to distinguish distinct sounds and identify the sound by marking down the sound # 1 if it was at 5 seconds, sound # 2 if it was at 15 seconds, and sound # 3 if it was at 30 seconds.

Assumptions and Limitations

The questionnaire had several assumptions and limitations. One assumption is that the subjects will be able to understand the mixture of voices and distinct sounds from a fire ground, as well as have physiological responses to the stimuli of real fire ground sounds.

Another assumption and limitation is that the recording of real fire ground ambience will have the same physiological response as being on the actual fire ground. However, using a decibel meter, the volume of the recording was set at the decibel range as on a real fire ground.

One limitation of the questionnaire was the small group of respondent's within Osceola County Emergency Services and the nine volunteer fire districts within Osceola County. A questionnaire distributed nationally may have provided additional information of Personal Alert Safety Systems devices. However, because of the time restraints to complete this paper, a smaller number of respondents were chosen. In addition, because of the small number of respondents sampled, the information may not be considered as representative of all firefighters and chief officers. Nonetheless, the information obtained was essential to this research.

A limitation with the clinical study was the cost of using a large number of subjects. Because of this, a small subject population was assessed making it difficult to conclude firefighter's physiological response to distress alert signals. Additionally, although the subjects appeared to be healthy and had no apparent hearing limitations, they could have had a deficiency in hearing. Another limitation was the possibility of a large response or peak amplitudes to the sounds due to the orienting reflex, a reflex that concentrates the body's attention to a new stimulus. However, orienting reflex is normally the first sound or question heard during a polygraph. Also, the subjects could affect the results by utilizing various counter measures.

Survey: Definition of Population

The questionnaire was given to forty (40) firefighters and chief officers from 10 different departments to analyze their perception of the activation of the Personal Alert Safety Systems device. The purpose of the questionnaire was to:

(1) Quantify the number of firefighters and chief officers that have heard the activation of Personal Alert Safety Systems devices on fire ground operations.

(2) Identify the number of firefighters and chief officers, who have heard the activation and did not perceive the activation as urgency.

(3) Identify the type of Personal Alerting Safety Systems devices utilized.

(4) Quantify the number of firefighters that turn manual Personal Alert Safety Systems devices on before entering hazardous or hostile environments.

Populations of the Survey

The population completing the questionnaire included 32 firefighters and chief officers from 10 fire departments.

Collection of Data

There were 32 questionnaires completed out of a possible 40 for an 80 percent response rate.

RESULTS

These results review answers to the research questions and results of the surveys and questionnaires.

Answers to Research Questions

Research Question 1. Are firefighters able to distinguish the numerous distinct events and sounds as a human listener from busy fire ground ambience? Historical research and literature reviews provided no information to address this question regarding if firefighters can distinguish distinct sounds from fire ground ambience. However, some research has been completed regarding the human listener in busy environments, such as a "city street" and his or her ability to distinguish sine tones and white noise. Therefore, interviews and a subjective listening clinical study were conducted to obtain an answer.

Extracting distinct events and sounds from a busy environment is essential for firefighters engaged in fire ground operations. Extracting these sounds give firefighters the ability to separate out a set of independent sources of sound and numerous distinct events, in order to perform fire suppression activities and make rescues. These distinct fire ground sounds appear as a featureless mess or clutter on a signal analysis, such as Microsoft Audio View (Appendix O). Without this ability firefighters as human listeners would only be able to interpret sounds when they occurred against a silent background (Warren 1993; Ellis, 1996; Norris, 2001, May 28).

The subjective listening clinical study followed by a brief interview indicated that firefighters were able to distinguish the numerous distinct events on the fire ground only 57 percent of the time. However, many of those interviewed indicated that they as human listeners have become complacent to many of the numerous fire ground sounds, such as engine noise, feedback from radios, and the Personal Alert Safety Systems device's distress tone. Those interviewed also stated that the auditory stimulus from the fire ground has to be relevant, as well as being visually alerted to something that would indicate a firefighter is in trouble

Ellis (1996) and Norris (2001, May 28) research suggested that the listener's perception of distinct events in ambient sounds in a busy environment, such as City Street might not be able to interpret the combination of difficult sounds. These difficult sounds are sometimes replaced with sounds needed to make estimates of the missing sounds. Ellis (1996) research also indicated that many times in busy environments a "… burst of noise will, under suitable conditions, be perceived as continuing through the noise, in spite of the fact that the sound stimulus was not constructed that way" (p. 49). Computational modeling has documented these bursts of noise as being continuous. The firefighter subjects during the subjective listening clinical study espoused Ellis (1996) research by stating that the mixture of multiple fire ground sounds and the distress signal seemed to be a continuous noise without interruption.

Using this same line of thinking it could be possible that the distress sound of the Personal Alert Safety Systems devices mixed in with the ambient sounds of the fire ground may be perceived as a continuous noise. Although this type of research is very controversial, computational modeling has the ability to separate out sounds that many times are perceived as a continuous noise. This may be one explanation why firefighters appear complacent to the sound of the distress tone after activation of the Personal Alert Safety Systems device.

Research Question 2. Are firefighter's responses becoming conditioned or are we shaping their behavior regarding the auditory stimuli of the distress alert tone from Personal Alert Safety System devices? Historical research and literature reviews provided no information to address this question directly. Because of the lack of research, it was believed that generalizablity theory would have to be used to determine if firefighters are becoming conditioned or their behavior shaped regarding the distress alert tone from Personal Alert Safety Systems devices. However, research in other areas of classical and operant conditioning, and shaping behavior provided strong evidence that this was probable. In addition, clinical studies were conducted using physiological challenges to determine stimulus response to the fire ground sounds to obtain an answer.

When firefighters recognize danger, perceive that other firefighters are in trouble, or both from the activation of Personal Alert Safety Systems devices' distress tone, previously conditioned behavior patterns should be triggered. These previously conditioned behavior patterns will enable the sympathetic nervous systems to assist in the rescue of the downed firefighter or the firefighter who is perceived to be in danger. However, false activations are lowering the arousal state of firefighters causing the firefighter to consciously choose to alter his or her response to the distress tone. Firefighters are becoming conditioned, as well as we are negatively shaping their behavior to the distress tones from the Personal Alert Safety Systems devices. This was documented by measuring the lack of physiological changes of the firefighters unconscious physiological responses to the auditory stimulus of the distress tone through the use of polygraph apparatus in Auditory Stimulus Test # 1, # 5, # 7 and # 8.

Research Question 3. Do physiological impairments associated with the firefighter's age affect stimuli reaching the auditory system? According to several biomedical and behavioral scientists, and health care providers at the National Institutes of Health Consensus Development Conference on Noise and Hearing Loss (1990, January 22-24) physiological impairments are affected by age resulting in stimulus reaching the auditory system. The literature reviews indicate that there is very little difference in stimuli reaching the auditory system in young male and female children below 10 years of age. However, from the age 10 to the age 20 males begin to show reduced high-frequency auditory sensitivity relative to females (Noise and Hearing Loss, 1990, January 22-24). Literature reviews attributed this to the probability that males are exposed to excessive noise rather than inherent vulnerability. On other hand, although they differ slightly on the frequencies range, several authors, such as Alford (2001, April 31), Campbell (1990), Patterson (2001, May), and Vernick (1993), based the hearing loss on the existence of presbycusis, hearing loss that increases with age and is not believed to be attributed to excessive noise.

Research Question 4. What are some of the limitations and deficiencies of the Personal Alert Safety Systems devices? There were numerous types of Personal Alert Safety Systems devices mentioned in the literature reviews, such as:

1. American Signal Corp
2. Diktron's Quic-Alert Rescue Alarm
3. Draeger Safety Inc.
4. Falcon Direct Inc.
5. Grace Industries Inc.
6. King-Fisher Co.
7. LifeGard V PASS
8. LifeGardTM V Personal Alert Safety System
9. Lifeline Safety Products
10. L. N. Curtis and Sons
11. M & S Fire and Safety Inc.
12. MSA
13. Priority 1 Life Safety Strobe
14. Securus

15. Visibility Systems Co.

16. Ziamatic

Several authors, such as Smith and Withington (2000, January), and Rubin and Rio (1986, November), proposed that they were concerned with the effectiveness of the Personal Alert Safety Systems device as a distress signal unit. The literature reviews indicated that the alerting devices have been changed very little over the last 20 years. Because of this little change, Smith and Withington (2000, January) wrote that the personal alerting devices "have a crucial deficiency for such a potentially life-saving piece of equipment" (p. 27). A limitation and deficiency noted by Smith and Withington (2000, January) was that the current models emitted a high frequency, single tone signal of approximately 90Hz (3kHz), which is not ideal in terms of perceived urgency. The sound intensity of 90 decibels is normally within six (6) feet of the distress unit in free air.

Another limitation noted by several authors, such as Rubin and Rio (1986, November) and Smith and Withington (2000, January) stated the distress alert signals were difficult to isolate. This same limitation was mentioned in several articles where several PASS devices were activated and the rapid intervention teams (RIT) were unable to immediately localize the alert tone and had to rely on a standard search pattern, losing valuable seconds.

Another limitation mentioned in the literature review, as well as in the survey was that the Personal Alert Safety Systems devices activate or false alarmed so often that they were turned off. However, the respondent's interpretation of false alarmed was not clear and had several meanings from the PASS device activating when standing still, activating when aggressive fighting fire while kneeling in a hallway, to just activating.

One deficiency mentioned by the National Fire Data Center United States Fire Administration Federal Emergency Management Agency (2000, July) in *Firefighter Fatalities in the United States in 1999* was that three members of the Keokuk (Iowa) Fire Department were killed in an apartment fire due to a flashover. The Personal Alert Safety System devices were integrated with their Self Contained Breathing Apparatus and failed to sound. However, the cause of death was not attributed to the PASS devices.

Another deficiency is that many PASS devices are manual and not integrated into the Self Contained Breathing Apparatus, which allow firefighters the option of disarming or turning off the device.

Research Question 5. What are some of the advantages of the Personal Alert Safety Systems devices? Literature reviews indicated that the primary advantage of Personal Alert Safety System devices is that they save firefighters' lives. The National Fire Data Center United States Fire Administration Federal Emergency Management Agency (2000, July) suggests that a number of firefighter fatalities could have possibly been prevented if the safety equipment had been activated. Because of this, the United States Fire Administration Federal Emergency Management Agency in their report *Personnel Accountability System Technology Assessment* (1996) suggested that integrating the Personal Alert Safety Systems device into the Self

Contained Breathing Apparatus (SCBA) will assure that the device will automatically activate when the SCBA is turned on, therefore, possibly saving lives.

Research Question 6. Is a polygraph apparatus that evaluates physiological biofeedback useful for data acquisition in determining firefighters' responses to the distress tone of Personal Alert Safety Systems devices? A polygraph test measures various physiological responses, including respiration rate, perspiration, heart rate, and blood pressure. According to the American Polygraph Association's web page http://www.polygraph.org, polygraphs are very accurate to changes which take place inside the body during responses to any stress or physiological challenge. However, they are too unreliable and inconclusive to be regarded as evidence per court rulings. Although polygraph apparatus are primarily utilized for testing to indicate the truth, Bill Frazier (personal communication, June 20, 2001) stated that polygraph apparatus are very reliable to evaluate any physiological change that is associated with stress, such as hearing a distress signal from a Personal Alert Safety Systems as long as it causes a physiological challenge.

RESULTS OF THE SURVEY

Demographic Characteristics for Osceola County Emergency Services

Twelve chief officers and firefighters of the Osceola County Emergency Services completed the survey. Most respondents reported 6-10 years of service representing 42 percent, respectively.

The majority of the sample population included firefighters (75 percent), followed by chief officers (25 percent).

Males made up 92 percent of the population. The majority of the sample group was between 26-30 years of age.

One hundred percent (100%) of the survey group was Caucasian. Five percent (5%) of those cited Hispanic heritage.

Additional demographic information can be found in Appendix D.

Demographic Characteristics for Osceola County Volunteer Fire Districts

Twenty volunteer chief officers and firefighters of the nine fire districts within Osceola County completed the survey. Most respondents reported 1-5 and 16-20 years of service representing 55 percent and 25 percent respectively.

The majority of the sample population included firefighters (55 percent), followed by chief officers (45 percent).

Males made up 80 percent of the population. The majority of the sample group was between 19-35 years of age.

One hundred percent (100%) of the survey group was Caucasian. Twenty five percent (25%) of those cited Hispanic heritage.

Additional demographic information can be found in Appendix E.

Most Significant Demographic Data

The most significant demographic data of the 80 percent chief officers and firefighters surveyed, whether volunteer or career, is that the majority had only a high school education or some college. Table 1 illustrates the responses based on department type and the corresponding response percentage.

Table 1.
Number of Responses Based on Education.

Education	Career	Percent	Volunteer	Percent
High School	2	17%	12	60%
Some College	5	42%	5	25%
College--Associate of Arts/Associate of Science	4	33%	2	10%
College--Bachelor of Arts/Bachelor of Science	1	8%	1	5%
College--Graduate Degree or Graduate Classes	0	0%	0	0%

The Questionnaire

Part I of the questionnaire requested that each respondent check his or her response to the activation of the Personal Alert Safety Systems (PASS) devices on emergency and non-emergency incidents. The most significant answer was the respondents heard the activation of Personal Alert Safety Systems (PASS) devices, followed by PASS activation with no perceived urgency. Table 2 lists the responses based on department type and the corresponding response percentage.

Table 2.
Reaction to the Activation of Personal Alert Safety Systems Devices Observed on Fire grounds.

Activation Of Pass Devices	Career	Percent	Voulnteer	Percent
Heard the activation of Personal Alert Safety System (PASS) devices	11	91%	18	90%
Not heard the activation of Personal Alert Safety System (PASS) devices	1	8%	2	10%
PASS activation with no change in fire ground operations	11	91%	15	75%
PASS activation with no perceived Urgency	11	91%	17	85%
PASS activation while engaged in fire suppression activities	10	83%	5	25%
PASS activation while waiting for assignment	10	83%	15	75%
PASS activation while in rehab	5	41%	2	10%
Experience false PASS activation	11	91%	4	20%
Experience PASS activation from temperature-sensitive devices	0	0%	5	25%
Experience PASS activation from electronic-transmitting devices	0	0%	0	0%
Other--automatic PASS activation when removed from the apparatus	0	0%	4	20%

Part II of the questionnaire requested information concerning the type of PASS devices currently used and if the respondent activated the device prior to entering hazardous or hostile environments. The most significant answer was the majority, 72 percent of PASS (career and volunteer firefighters) devices were manually activated and of those 62 percent of the respondents with manually activated PASS devices did not activate the device because the device was a nuisance. Table 3 lists some of the respondents' selected responses.

Table 3.
Type of Personal Alert Safety Systems (PASS).

Type Of Pass Device	**Career**	**Percent**	**Volunteer**	**Percent**	**Activate Pass Device Prior To Entering A Hazardous Environment**
Manual PASS device	9	75%	14	70%	10% reported activation of the PASS device, 62% reported it was a nuisance
Manual PASS with temperature-sensitive devices	0	0%	3	15%	Yes
Manual PASS with electronic-transmitting devices	0	0%	0	0%	0
Partially integrated SCBA-PASS devices	0	0%		0%	0
Partially integrated SCBA-PASS with temperature-sensitive devices	0	0%	0	0%	0
Partially integrated SCBA-PASS with electronic-transmitting devices	0	0%	0	0%	0
Fully integrated SCBA-PASS device	3	25%	0	0%	Yes, automatic
Fully integrated SCBA-PASS with temperature-sensitive devices	0	0%	0	0%	0
Fully integrated SCBA-PASS with electronic-transmitting devices	0	0%	0	0%	0
Other type of PASS devices not listed above	0	0%	3	15%	Yes, automatically activated when removed from apparatus

Results of the Clinical Study for Physiological Response

Graph A (Appendix G) represents the subjects' physiological responses to complex fire ground ambience of heavy fire inside a structure and the fire suppression operation changing from offensive to a defensive mode with Command requesting for a PAR (personal accountability report) and the pre-alert sounds of a PASS device.

Auditory Stimulus Test # 1

Comparing non-firefighter subjects to firefighter subjects revealed a significant difference in only one of the subjects in each of the groups. Subject 2 (firefighter) and Subject 5 (non-firefighter) had physiological changes in their respiration rate and Galvanic Skin Response (GSR) when the auditory stimulus was a female firefighter acknowledging that she was out of the structure after Command requested a PAR and the pre-alert sound of a PASS device was in the background.

Graph B (Appendix H) represents the subjects' physiological responses to an individual distinct sound of engine noise from a fire apparatus changing pitch as the RPM increases because of a pressure change due to flowing water.

Auditory Stimulus Test # 2

None of the subjects demonstrated a physiological response.

Graph C (Appendix I) represents the subjects' physiological responses to engine noise from a positive pressure fan as the engine stalls and then is re-cranked.

Auditory Stimulus Test # 3

The comparison indicated no physiological events.

Graph D (Appendix J) represents the subjects' physiological responses to an anxious mother stating her baby was still inside the structure.

Auditory Stimulus Test # 4

The comparison indicated that all the subjects except Subject 1 (firefighter) and Subject 8 (non-firefighter) had significant physiological changes in skin resistance, blood pressure, respiration rate, and heart rate.

Graph D (Appendix K) represents the pre-alert tone of a PASS device.

Auditory Stimulus Test # 5

Comparing non-firefighter to firefighter subjects indicated no physiological response.

Graph E (Appendix L) represents Command's acknowledgement of heavy fire on Side 3.

Auditory Stimulus Test # 6

Demonstrated no physiological responses to either the non-firefighter or the firefighter subjects.

Graph F (Appendix M) represents the activation of a PASS device from a distance.

Auditory Stimulus Test # 7

In this test, Subject 1 was the only one to demonstrate physiological changes in respiration rate to this stimulus. However, some of the respondents indicated large orienting reflex to the first sound of the distress tone which indicated the subject's attention to the new stimulus.

Graph G (Appendix N) represents the activation of a distress tone from a PASS device up close.

Auditory Stimulus Test # 8

In this test, all the subjects indicated an orienting reflex through physiological changes in response to the distress tone. However, after the brief orienting reflex, indicated by the physiological event in Galvanic Skin Response (GSR) each of the subjects became relaxed and the arousal state or orienting reflex was lowered to normal.

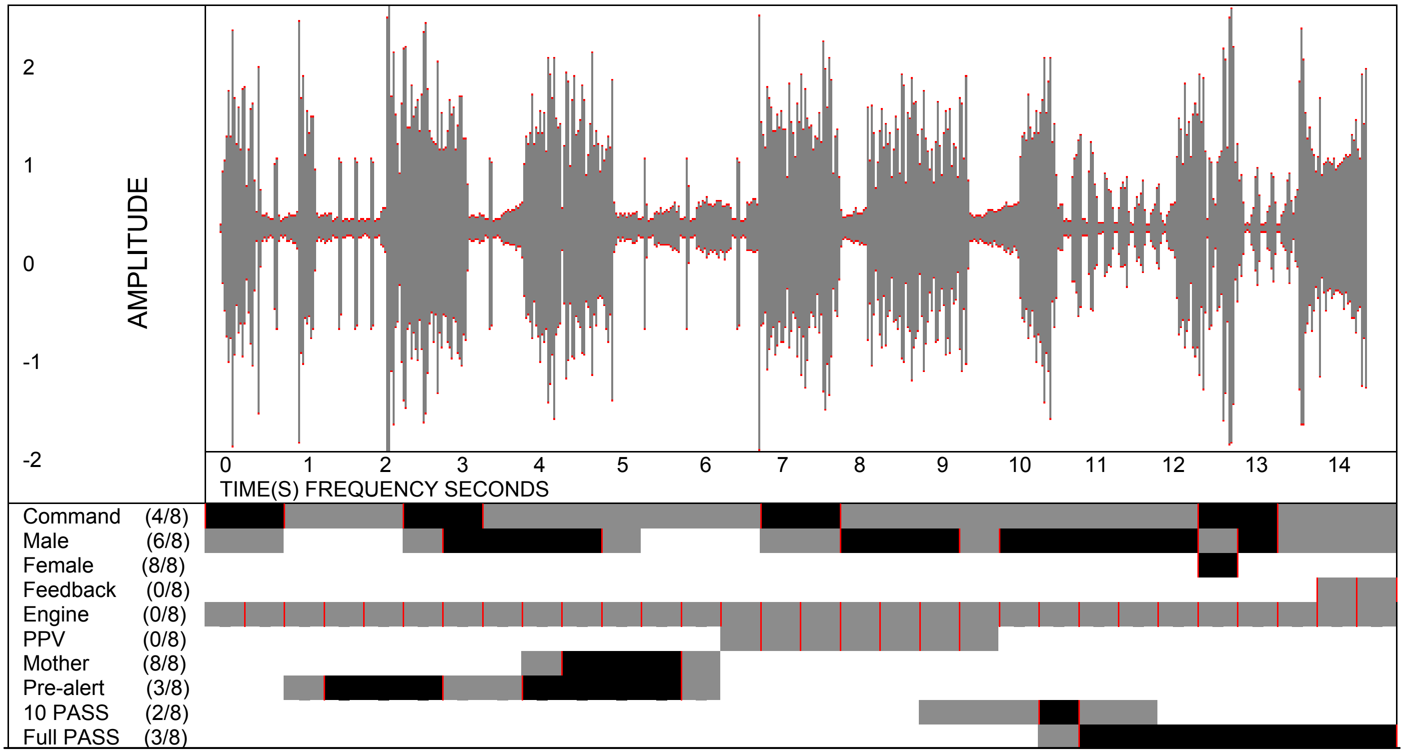
Results of the Clinical Study for Subjective Listening Test

In this test fire ground ambience which consisted of the above 8 distinct sounds were mixed into the recording with background noise from the scene to test the subject's perception of a real-world complex sound mixture from a fire ground (visual representation of each of the sounds utilizing Microsoft Audio View are found in Appendix O). Table 4 illustrates the 8 distinct responses from the subjective listening test and indicates the number of times the subjects were able to identify the distinct fire ground sounds. Table 5 illustrates the waveform showing the difference in maximum peaks of the perceived sound events for the fire ground ambience sound. The gray bar shows the onset and offset of the auditory stimulus. The black bar shows the correct responses from the auditory stimulus events during the subjective listening test.

Table 4.
Subjective Listening Test Results.

Test	Auditory Stimulus	Event	Right	Wrong	Precent
Auditory Stimulus Test #1	Fire ground ambience of heavy fire inside a structure and the operation changing to a defensive mode with Command requesting for a PAR (personal accountability report) and the pre-alert sounds of a PASS device,	"male" "female" "PASS" "PAR" "interior" "engine" "feedback"	6/8 8/8 3/8 4/8 0/8 0/8 0/8	2/8 0/8 5/8 4/8 8/8 8/8 8/8	25/75 100/0 37/63 50/50 0/100 0/100 0/100
Auditory Stimulus Test #2	Engine noise from a fire apparatus changing pitch as the RPM increases because of a pressure change	"engine"	1/8	7/8	13/87
Auditory Stimulus Test #3	Engine noise from a positive pressure fan stalling and then being cranked	"PPV"	0/8	8/8	0/100
Auditory Stimulus Test #4	A anxious mother stating her baby was still inside the structure	"mother"	8/8	0/8	100/0
Auditory Stimulus Test #5	The pre-alert tone of a PASS device	"PASS"	3/8	5/8	37/63
Auditory Stimulus Test #6	Command's acknowledgement of heavy fire on Side 3	"male 1" "male 2" "male 3" "male 4"	4/8 6/8 7/8 6/8	4/8 2/8 1/8 2/8	50/50 75/25 87/13 75/25
Auditory Stimulus Test #7	The activation of a PASS device from a distance	"PASS"	3/8	5/8	37/63
Auditory Stimulus Test #8	The activation of a distress tone from a PASS device up close	"PASS"	3/8	5/8	37/63

Table 5.
Waveform Showing Difference in Maximum Peaks of the Perceived Sound Events for the Fire Ground Ambience and Distinctive Sounds for the Subjective Listening Test. (Time-frequency).



DISCUSSION

It is the consensus from questionnaires and the opinion of those interviewed that it is common to hear Personal Alert Safety Systems devices' distress signal activated under emergency and non-emergency conditions. In addition, it was common to see firefighters not respond immediately to the activation of the distress signal. The respondents did not relate these incidents to the possibility of impaired hearing, or the possibility of physiological impairments due to the firefighters' age. However, it was the opinion of those interviewed after the clinical study that some other type of distress signal is needed to augment existing systems due to firefighters being complacent to the current distress tones because the tones are not being perceived as urgency. Several firefighters and chief officers espoused that this may be because firefighters are being discriminative in their responses due to the number of false activations of the distress alert tone from a PASS device. In addition, many of the respondents felt that this discriminative type of response is being reinforced by the lack of punishment for violating their Department's Standard Operating Guidelines (SOG).

Additionally, academic literature and trade journal literature reviews indicated physiologic tests were performed on Personal Alert Safety Systems devices. These tests were to evaluate the devices in terms of heat and flame contact, waterproofness, if the device is intrinsically safe, and to determine the activation of PASS devices from exposure to either freezing or high temperatures (Burris, 2000, July). However, none of the testing procedures discussed in the literature review addressed the issue of the distress tones being perceived as urgency.

Statistics in the academic literature and trade journal literature reviews espoused that a majority of firefighter deaths are due to becoming lost within a structure on fire due to disorientation, as well as the lack of personal protective clothing and equipment that would alert others to prevent tragic incidents involving the loss of firefighter's lives. However, literature reviews indicate these are not the only reasons for the tragic loss of firefighters and many times the loss was due to the fact that PASS devices were not activated. Nonetheless, there is a gradual trend towards fewer firefighter fatalities because of personal protective clothing and the PASS devices. Academic literature reviews also suggest that there is a serous dilemma in how the distress alert tone is perceived, as well as localized because the sound bounces off of walls and floors inside the structure.

Physiological response clinical studies found that the majority of the firefighter subjects indicated no response or graphical output to the mixture of sounds from fire ground ambience even though they could distinguish the pre-alert and alert distress signal of the Personal Alert Safety Systems devices in the subjective listening studies. In addition, the clinical studies found that firefighter subjects had no physiological responses to multiple distinct sounds indicated by no graphical output during the test which should have indicated an interaction of internal and external stressors as the firefighter subjects recognized that other firefighters were in danger from the audio stimulus when Command requested a PAR from all the units on the scene and panicked voices indicating that they were out of the structure. However, memory and foresight from actual fire ground operations may have given the firefighter subjects the ability to anticipate the auditory sounds and consciously choose to alter responses because of the number of activations of the distress alert signals from PASS devices and not relating to the panic stricken voices.

Non-firefighter subjects could not distinguish the different distinct fire ground sounds in the subjective listening studies other than the voices of fire ground operations which they thought were in another language because of not knowing fire ground terminology. However, the non-firefighter subject had the same response as firefighter subjects to the distress tone. This was indicated during the physiological biofeedback of Audio Stimulus # 1 with the majority of non-firefighter subjects showing no physiological event or graphical output to the auditory stimulus of firefighters in trouble and the distress tone. One reason given was because each of the non-firefighter subjects thought the distress tone from the PASS device was the activation of a car alarm or smoke alarm. Nonetheless, one female non-firefighter responded to one of the firefighters voices stating that Rescue 11 was out of the structure.

In the Auditory Stimulus Test # 2, # 3, # 5, # 6 and # 7 when the distinct fire ground sounds were separated from the background noise, the majority of firefighter subjects did not respond to the distinct sounds. However, the majority of firefighters responded to Audio Stimulus Test # 4 and # 8. Audio Stimulus Test # 8 only had an initial response of graphical output known as an orienting reflex to the new stimulus and then returned to a normal physiological event with no graphical output, indicating that the respondents reacted to the initial auditory stimulus of the 90 decibels and not to the continuous distress alert signal. This indicated that each respondent heard the distress tone, but the signal was not perceived as urgency. The same results occurred with non-firefighter subjects who responded to the initial Auditory Stimulus Test # 8 as an orienting reflex and then not to the continuous distress alert signal. These results could emphasize the role of the fire ground environment in shaping behavior through classical conditioning and operant conditioning by the ability to consciously choose to alter responses for firefighters. However, the question would be why did non-firefighters have the same graphical output or physiological event as firefighters. After the clinical study each non-firefighter stated that the distress alert signal startled them at first and then became annoying just like car alarms or smoke detectors and firefighter subjects stated the distress tone was a nuisance.

Subjective listening clinical studies found that there is a multiple mixture of distinct fire ground ambience, which are difficult to distinguish by subjects who are both firefighters and non-firefighters, as well as a featureless mess on Microsoft's Audio View (Appendix O). However, the firefighter subjects were able to distinguish more of the distinct fire ground sounds out of the multiple mixtures more often than the non-firefighter subjects (Table 4). Ellis' (1996) research suggested that the listener's perception of distinct events in ambient sounds in a busy environment, such as City Street may not be able to interpret the combination of difficult sounds and these difficult sounds are sometimes replaced with sounds needed to make estimates of the missing sounds. Ellis' (1996) research was espoused during the subjective listening clinical studies where some of the firefighter subjects were unable to distinguish the Personal Alert Safety Systems devices from busy fire ground ambience.

Ellis' (1996) research also indicated that many times in busy environments a "burst of noise will, under suitable conditions, be perceived as continuing through the noise, in spite of the fact that the sound stimulus was not constructed that way" (p. 49). Therefore, using this same line of thinking it could be possible that the distress sound of the Personal Alert Safety Systems devices mixed in with the ambient sounds of the fire ground may be perceived as a continuous noise. This may be one explanation why the firefighter subjects did not always distinguish the distress tone and firefighters on fire ground operations appear complacent to the sound of the distress signal after activation of the Personal Alert Safety Systems device.

The physiological response clinical study indicated that the majority of the firefighter subjects did not have any involuntary responses to the distress signal of the Personal Alert Safety Systems devices other than the orienting reflex. Additionally, the subjective listening clinical study indicated that firefighters did not recognize the distress tone separated from the mixture of fire ground ambiences. One theory could be the fire ground sounds have masking properties which do not allow for the detection of the distress signal from different peripheral frequencies similar to the distress signal. However, no meaningful conclusions can be drawn from a comparison of both the physiological response clinical study and the subjective listening study other than the lack of physiological response to the distress signal and not perceiving the distress tone as urgency. Nonetheless, the clinical studies gathered some 'ground truth' regarding the perception of the distress signal and lends toward the theory that firefighters have been conditioned not to respond immediately to the PASS devices distress tone. For instance, the relationship with the Personal Alert Safety Systems device in classical conditioning is the activation of the distress alert tone, the unconditioned stimulus (US), guides the approach behavior of the firefighter; the conditioned stimulus (CS) activation of the sympathetic nervous system's autonomic, or involuntary nervous systems to prepare the firefighter to respond to the distress alert tone because of fear that a firefighter was injured; the unconditioned response (UR) that is performed when unconditioned stimulus (US) is presented; and, finally the conditioned response (CR) that is executed when the conditioned stimulus is presented of immediately stopping whatever the firefighter was doing and orients toward the source of stimulation. If the distress alert tone is perceived as life threatening to another firefighter, the unconditioned response (UR) will be produced. However, when the firefighter cannot respond because it is a false activation of the distress alert tone, the conditioned response (CR) of sympathetic nervous system will be performed instead. Over a period of time the strength of the expectation that the unconditioned stimulus (US) will follow the conditioned stimulus (CS) as the expectations normally perceived from the activation of the Personal Alert Safety Systems device will not occur and the reduction of the learned fear, in turn, reinforced the extinction of fear in the presence of conditioned cues.

Operant conditioning is best thought of as associative learning through the result of consequences. For instance, the Personal Alert Safety Systems device in operant conditioning is the activation of the distress alert tone, the reinforcement is that the consequence which shapes the behavior was not an emergency and makes the response more common because of the number of false activations heard on the fire ground. When the false activation of the distress signal recurs, it is not a perceived urgency and the behavior is reinforced. Without some type of punishment to change this behavior, this continuous reinforcement of the distress signal not being a true emergency will generally be most effective in creating a new behavior of not immediately responding to the distress alert signal because the arousal states are lowered. However, this continuous reinforcement would have to be the same consequence that follows the behavior each time after the activation of the Personal Alert Safety Systems device.

Classical and operant conditioning are not simple, and cognitive processes are involved. Therefore, this researcher argues that in order to properly evaluate Personal Alert Safety Systems, the use of computer-based physiological biofeedback assessment will be required to measure unconscious physiological responses to the distress alert signals in order to determine which signals are perceived urgency. In addition, behavior is affected by the consequences (Feldman, 1999) and continuing this process of not responding immediately to the distress signal will reinforce this behavior as long as the environment tolerates the behavior. Therefore, chief officers need to modify and reinforce appropriate thinking patterns through cognitive and reinforcement learning of responding immediately to the distress alert signals.

RECOMMENDATIONS

In today's fire service, due to the variety of Personal Alert Safety Systems available, we have an unfortunate tendency to overlook some of the most critical performance features of the distress alerting device, that of the perceived urgency of the alert signal. The NFPA standards established performance criteria that reduce many limitations for firefighters wearing the PASS devices and the perception and cognition of firefighters is that the PASS devices activation will elicit an immediate response to the distress signal. However, NFPA does not have any performance criteria for determining if PASS devices produce any sense of urgency through the distress tone. Nonetheless, this research has identified the need for physiological biofeedback analysis to determine if the distress tone produces a distress signal that firefighters perception and cognition is that of urgency for the life safety of another firefighter.

Osceola County Emergency Services Department will not be able to utilize physiological biofeedback applications for evaluating the urgency of the variety of PASS devices currently on the market due to the cost of each of the evaluations. Eventually, the cost of computer-based biofeedback will decrease, which will allow firefighters and chief officers to evaluate PASS devices before selection and procurement. However, until then, there is still the tremendous need to effectively evaluate PASS device's effect on firefighter's response during emergency and non-emergency incidents. The recommendation of this researcher is for an agency, such as the National Fire Academy or the National Fire Protection Association (NFPA), to do further research using computer-based physiological biofeedback, and to establish performance criteria to evaluate PASS devices and their effect on firefighter's sense of urgency to the distress signal. In addition, this research will be submitted to the NFPA Technical Committee through the public proposal process. Although this research indicated that firefighters appear to be conditioned to perceive the distress tone as a false activation, because of the small subject population it is difficult to conclude that all firefighters have been conditioned not to respond immediately to the distress tone and have no physiological response to the distress signal. Nonetheless, this research demonstrated that the firefighter and non-firefighter subjects did not have physiological changes to the distress signal and firefighters may have become conditioned not to respond immediately to the distress tone unless other stimuli are provided putting firefighters at a higher risk of death or injury due to the delayed response. Lastly, it is hoped that through the categories of logical persuasion, common vision, and participation and trust learned in *Executive Leadership* this research may persuade others to study why firefighters are not responding immediately to the activation of the Personal Alerting Safety Systems device while firefighters are engaged in heavy suppression activities, search and rescue activities, or both in order to save firefighters' lives in the future.

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Appendix A
Survey Cover Letter for Osceola County

Chief Officers and Firefighters
Osceola County Emergency Services Department
Volunteer Fire Districts

Dear Fellow Chief Officers and Firefighters:

Presently I am in the National Fire Academy's Executive Fire Officer Program, and as a part of my studies I am required to do a research paper. I have chosen to research stress related psychological events regarding the activation of Personal Alert Safety Systems device's distress signal and if we are shaping the behavior of firefighters responding immediately to the distress signal.

Your full participation in this research will involve: (1) your completion and return of the enclosed two part questionnaire, and (2) your completion of the demographic background sheet.

For confidential reasons, names will not be needed or required. I will be the only person who will be able to link your name with the information you provide. After all my statistics have been compiled and analyzed, the demographic sheets will be separated from the questionnaire.

In order to insure that the results are valid, please do not discuss the questionnaire with fellow firefighters. It is vital that I receive information from you that has not been influenced by anyone else.

After the study has been completed, the results will be available from me upon request.

Thanks in advance for your time and participation in this study.

Sincerely,

Donald R. Adams, Sr., Director/Fire Chief
Osceola County Emergency Services Department

Appendix B
Demographic Sheet

Please check the appropriate category for each section below.

1. YEARS IN THE FIRE SERVICE:

- ☐ 1 to 5 years
- ☐ 6 to 10 years
- ☐ 11 to 15 years
- ☐ 16 to 20 years
- ☐ 21 to 25 years
- ☐ 26 years

2. RANK

- ☐ District Chief
- ☐ Assistant Chief
- ☐ Deputy Chief
- ☐ Fire Chief

3. SEX

- ☐ Male
- ☐ Female

4. RACE

- ☐ Caucasian
- ☐ African-American
- ☐ Asian
- ☐ Other

HERITAGE

- ☐ Hispanic

Appendix B (Continued)

5. AGE

- ☐ 18-25
- ☐ 26-30
- ☐ 31-35
- ☐ 36-40
- ☐ 41-45
- ☐ 46-50
- ☐ 51-55
- ☐ 56-60
- ☐ 60+

6. EDUCATION

- ☐ High School
- ☐ Some College
- ☐ College — Associate of Arts/Associate of Science
- ☐ College — Bachelor of Arts/Bachelor of Science
- ☐ College — Graduate Degree or Graduate Classes

Appendix C
Questionnaire

Several studies have indicated that the greatest numbers of fatalities to firefighters are due to the lack of personal protective clothing and equipment. The assumption regarding equipment is that firefighters have become conditioned not to respond immediately to the activation of Personal Alert Safety Systems devices. As a firefighter or chief officer on emergency and non-emergency incidents, have you heard activations of Personal Alert Safety Systems devices? If so, please check the responses that you have seen and heard listed below. Please check all of the following that apply:

PART I

- ☐ Heard the activation of Personal Alert Safety Systems (PASS) devices
- ☐ Not heard the activation of Personal Alert Safety Systems (PASS) devices
- ☐ PASS activation with no change in fire ground operations
- ☐ PASS activation with no perceived urgency
- ☐ PASS activation while engaged in fire suppression activities
- ☐ PASS activation while waiting for assignment
- ☐ PASS activation while in rehab
- ☐ Experience false PASS activation
- ☐ Experience PASS activation from temperature-sensitive devices
- ☐ Experience PASS activation from electronic-transmitting devices
- ☐ Other (please describe):

Appendix C (Continued)

PART II

Please check the type of Personal Alert Safety Systems (PASS) that you currently have and identify if you activate the device prior to entering hazardous or hostile environments:

☐ Manual PASS devices

☐ Manual PASS with temperature-sensitive devices

☐ Manual PASS with electronic-transmitting devices

☐ Partially integrated SCBA - PASS devices

☐ Partially integrated SCBA - PASS with temperature-sensitive devices

☐ Partially integrated SCBA - PASS with electronic-transmitting devices

☐ Fully integrated SCBA - PASS device

☐ Fully integrated SCBA - PASS with temperature-sensitive devices

☐ Fully integrated SCBA - PASS with electronic-transmitting devices

☐ Other type of PASS devices not listed above:

____

____

____

____

____

____

____

____

☐ Please check if you activate the PASS device prior to entering hazardous or hostile environments.

If you do not activate the PASS device, please state why:

____

____

____

____

Appendix D
Demographic Characteristics For
Osceola County Emergency Services Department

Years in the Fire Service		
Number of years	Number of Personnel	Percentage
1-5	1	8%
6-10	5	42%
11-15	2	17%
16-20	3	25%
21-25+	1	8%

Rank	
Firefighter	Chief Officer
9	3
75%	25%

Sex	
Male	Female
11	1
92%	8%

Race				Heritage
Caucasian	African-American	Asian	Other	Hispanic
12	0	0	0	1
100%	0.0%	0%	0%	5%

Age		
Range	Number of Personnel	Percentage
19-25	0	0%
26-30	5	42%
31-35	3	25%
36-40	1	8%
41-45	2	17%
46-50	1	8%

Appendix D (Continued)

Education Educational Level:	Number of personnel	Percentage
High School	2	17%
Some College	5	42%
A.A./A.S.	4	33%
B.A./B.S.	1	8%
Graduate Degree or Graduate Classes	0	0%

Appendix E
Demographic Characteristics For Volunteer Fire Districts

Years in the Fire Service		
Number of years	Number of Personnel	Percentage
1-5	11	55%
6-10	1	5%
11-15	2	10%
16-20	5	25%
21-25+	1	5%

Rank	
Firefighter	Chief Officer
11	9
55%	45%

Sex	
Male	Female
16	4
80%	20%

Race				Heritage
Caucasian	African-American	Asian	Other	Hispanic
20	0	0	0	5
100%	0.0%	0%	0%	25%

Age		
Range	Number of Personnel	Percentage
19-25	5	25%
26-30	5	25%
31-35	5	25%
36-40	3	15%
41-45	2	10%
46-50	0	0%

Appendix E (Continued)

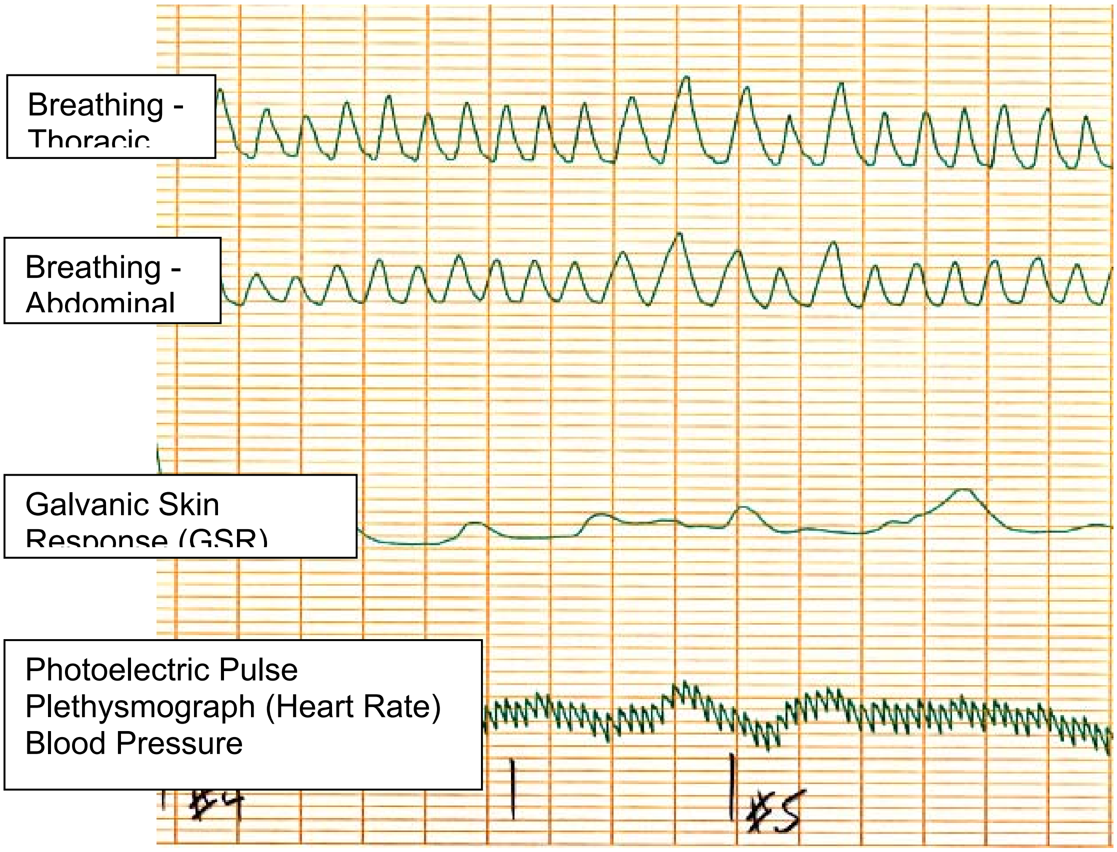
Education Educational Level:	Number of personnel	Percentage
High School	12	60%
Some College	5	25%
A.A./A.S.	2	10%
B.A./B.S.	1	5%
Graduate Degree or Graduate Classes	0	0%

Appendix F
Demographic Characteristics For Clinical Studies

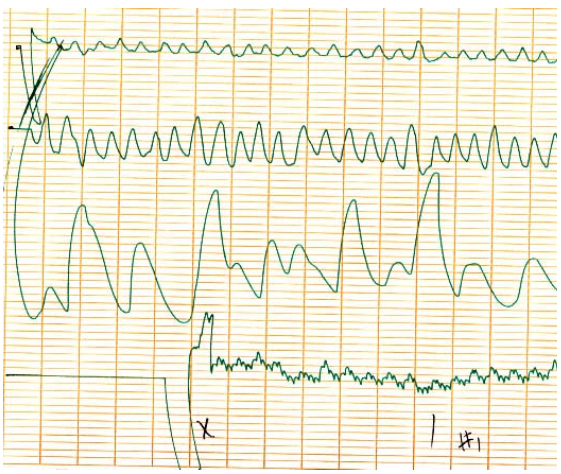
Subjects		**Years in the Fire Service**	**Age**	**Gender**
Subject 1	Firefighter	35	60	Male
Subject 2	Firefighter	18	38	Female
Subject 3	Firefighter	8	34	Male
Subject 4	Firefighter	21	45	Male
Subject 5	Non-firefighter	0	32	Female
Subject 6	Non-firefighter	0	54	Female
Subject 7	Non-firefighter	0	37	Male
Subject 8	Non-firefighter	0	45	Male

Appendix G
Physiological Event Graph Auditory Stimulus Test # 1

LEDGER



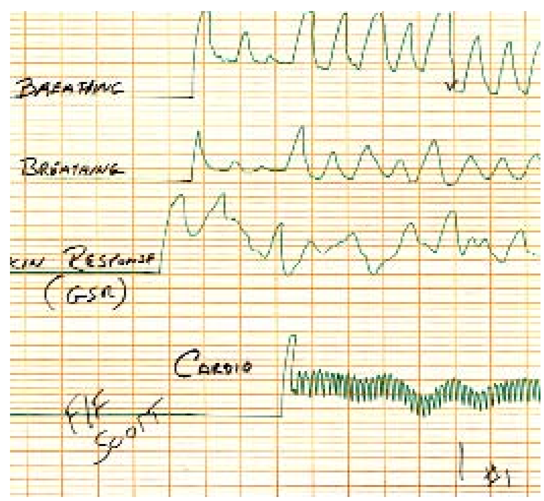
Appendix G (Continued)
Physiological Event Graph Auditory Stimulus Test # 1



Auditory Stimulus Test # 1 Subject 1:
No stress noted.

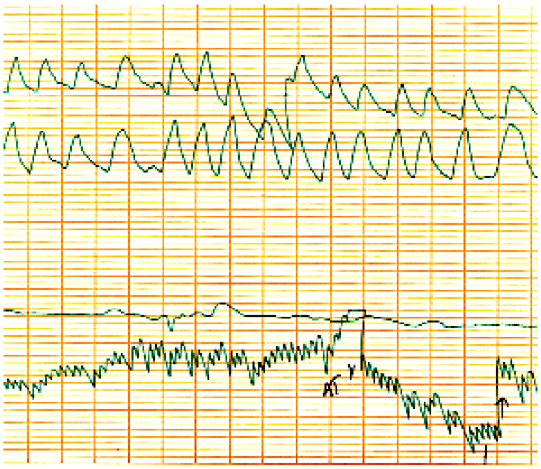
Auditory Stimulus Test # 1 Subject 2:
Stress noted in respiration rate and GSR.

Auditory Stimulus Test # 1 Subject 3:
No stress noted.

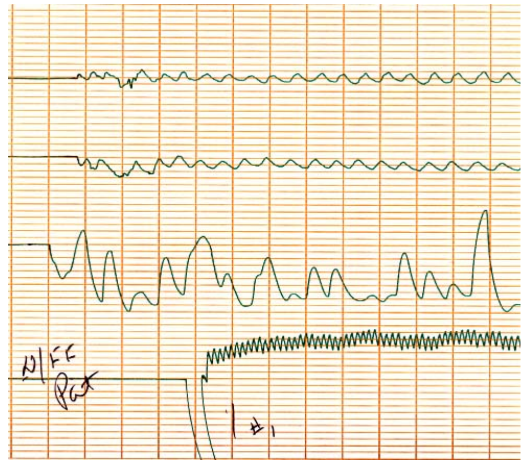


Auditory Stimulus Test # 1 Subject 4:
No stress noted.

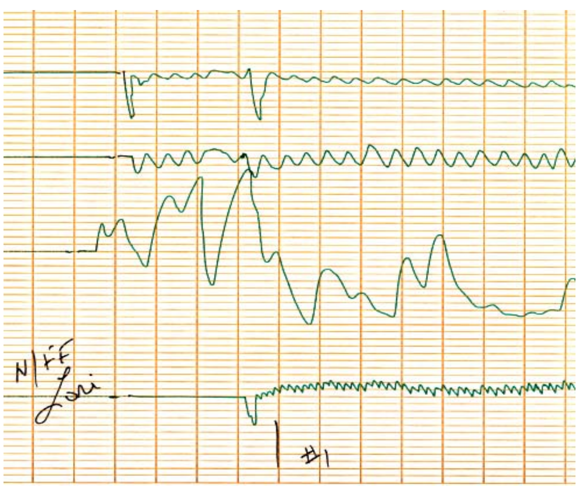
Appendix G (Continued)
Physiological Event Graph Auditory Stimulus Test # 1



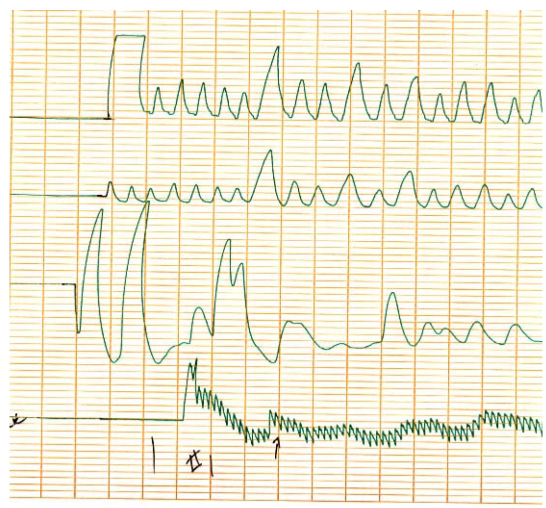
Auditory Stimulus Test # 1 Subject 5:
Stress noted in respiration rate and GSR



Auditory Stimulus Test # 1 Subject 6:
No stress noted.

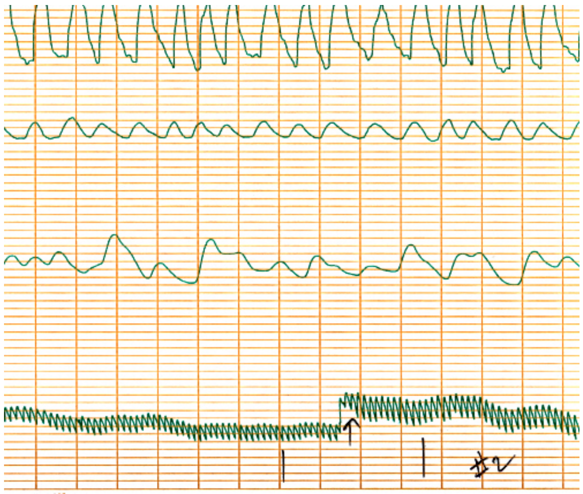


Auditory Stimulus Test # 1 Subject 7:
No stress noted.



Auditory Stimulus Test # 1 Subject 8:
No stress noted.

Appendix H
Physiological Event Graph Auditory Stimulus Test # 2



Auditory Stimulus Test # 2 Subject 1:
No stress noted.

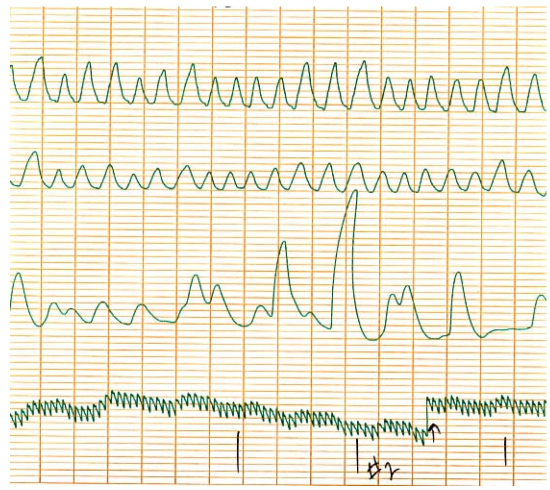
Auditory Stimulus Test # 2 Subject 2:
No stress noted.

Auditory Stimulus Test # 2 Subject 3:
No stress noted.

Auditory Stimulus Test # 2 Subject 4:
No stress noted.

Appendix H (Continued)
Physiological Event Auditory Stimulus Test # 2

Auditory Stimulus Test # 2 Subject 5:
No stress noted.

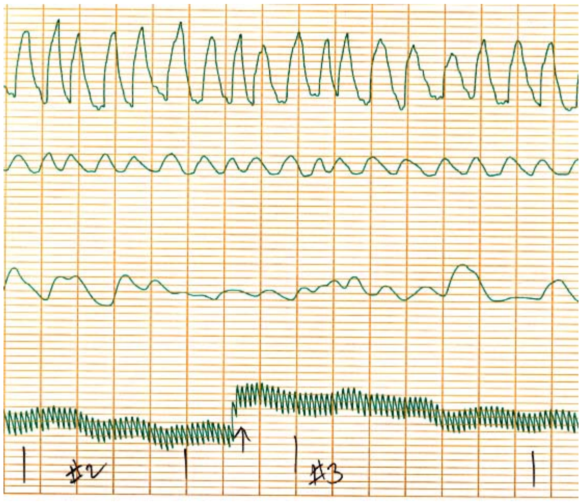


Auditory Stimulus Test # 2 Subject 6:
No stress noted.

Auditory Stimulus Test # 2 Subject 7:
No stress noted.

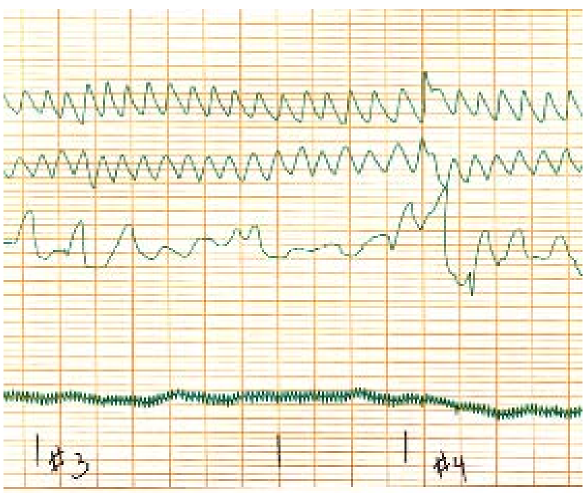
Auditory Stimulus Test # 2 Subject 8:
No stress noted.

Appendix I
Physiological Event Graph Auditory Stimulus Test # 3

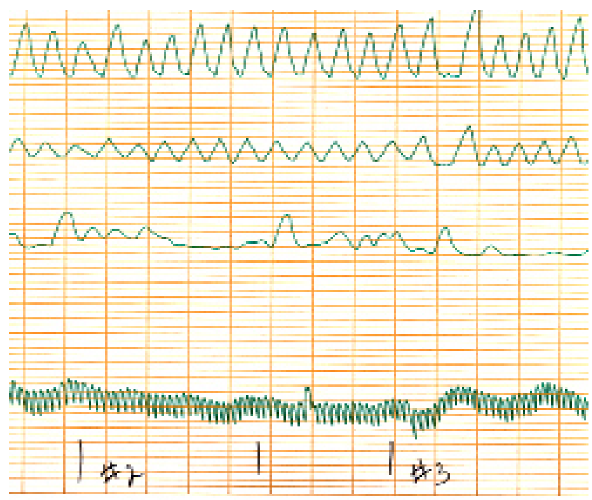


Auditory Stimulus Test # 3 Subject 1:
No stress noted

Auditory Stimulus Test # 3 Subject 2:
No stress noted.

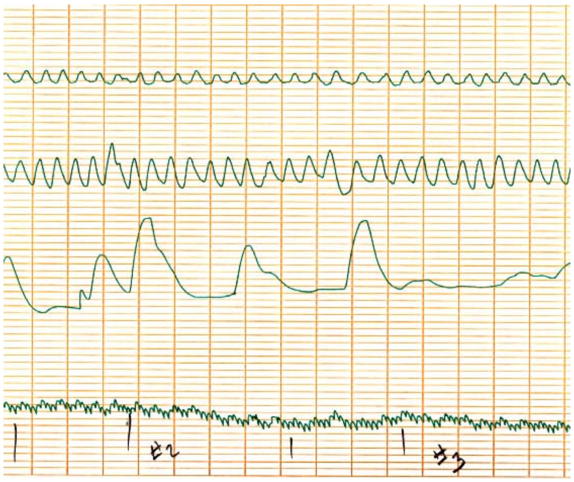


Auditory Stimulus Test # 3 Subject 3:
No stress noted.



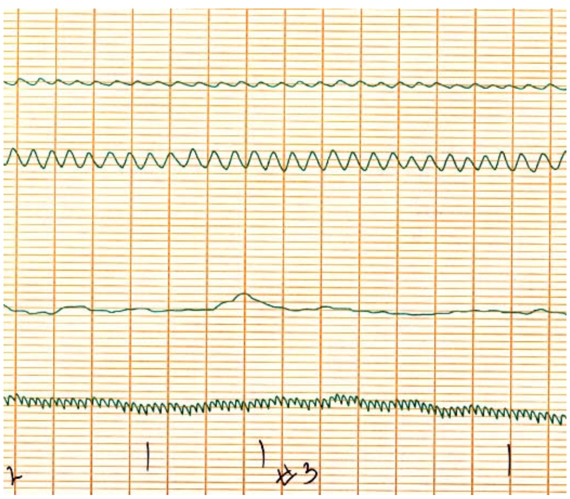
Auditory Stimulus Test # 3 Subject 4:
No stress noted.

Appendix I (Continued)
Physiological Event Auditory Stimulus Test # 3

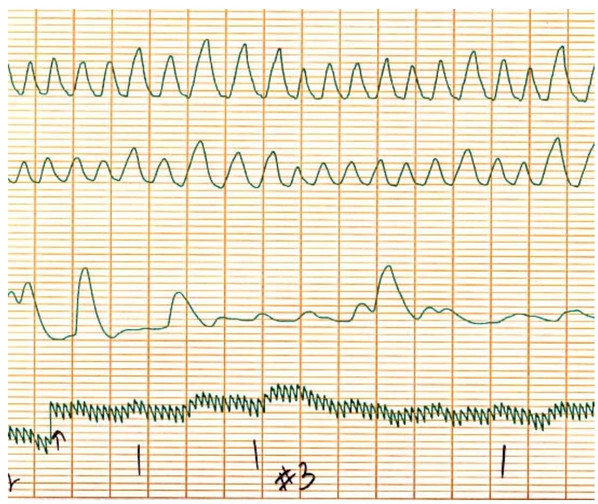


Auditory Stimulus Test # 3 Subject 5:
No stress noted.

Auditory Stimulus Test # 3 Subject 6:
No stress noted.

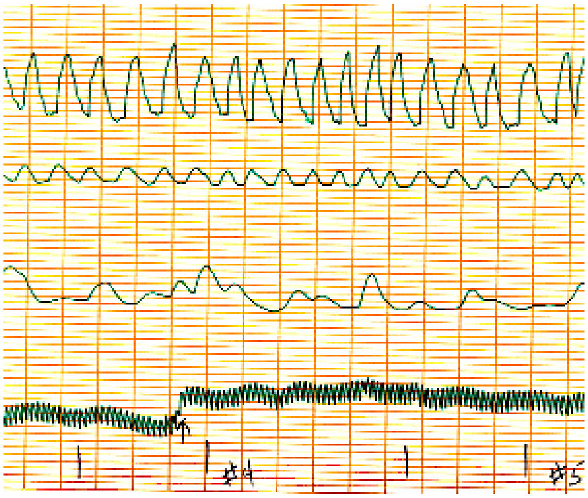


Auditory Stimulus Test # 3 Subject 7:
No stress noted.

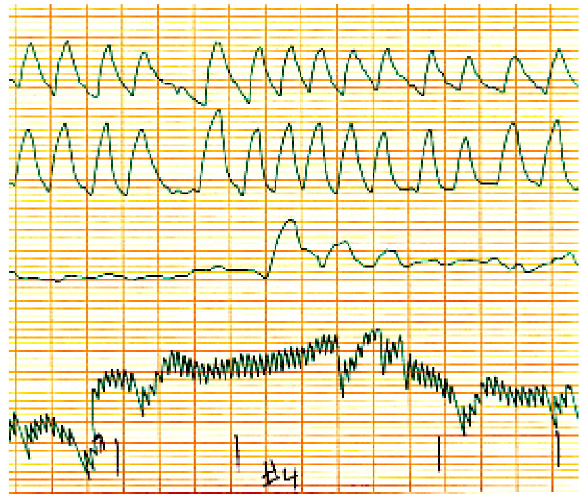


Auditory Stimulus Test # 3 Subject 8:
No stress noted.

Appendix J
Physiological Event Graph Auditory Stimulus Test # 4

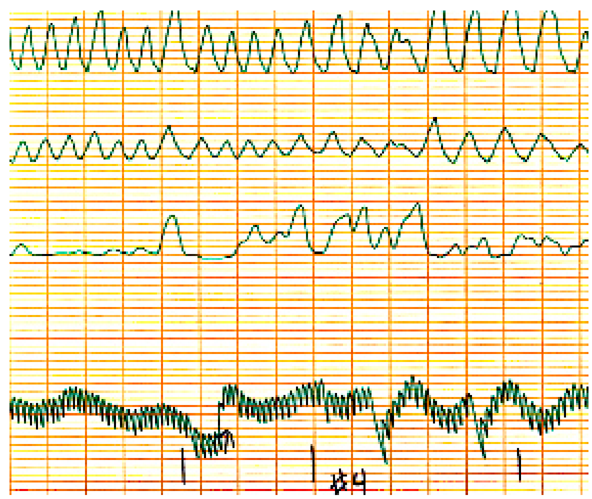


Auditory Stimulus Test # 4 Subject 1:
No stress noted



Auditory Stimulus Test # 4 Subject 2:
Stress noted in heart rate and respiration rate.

Auditory Stimulus Test # 4 Subject 3:
Stress noted heart rate and respiration



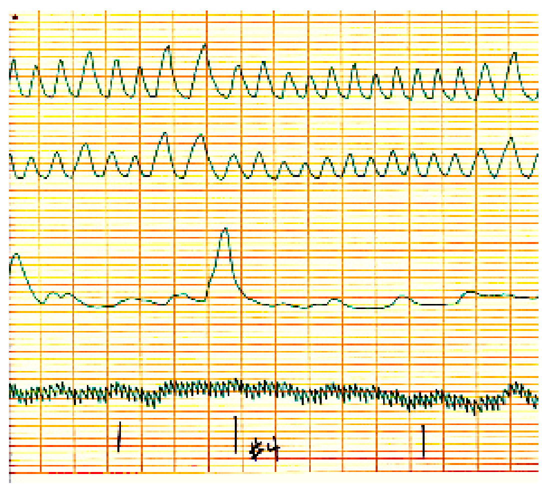
Auditory Stimulus Test # 4 Subject 4:
Stress noted heart rate and respiration rate.

Appendix J (Continued)
Physiological Event Auditory Stimulus Test # 4

Auditory Stimulus Test # 4 Subject 5:
Stress noted respiration rate and GSR.

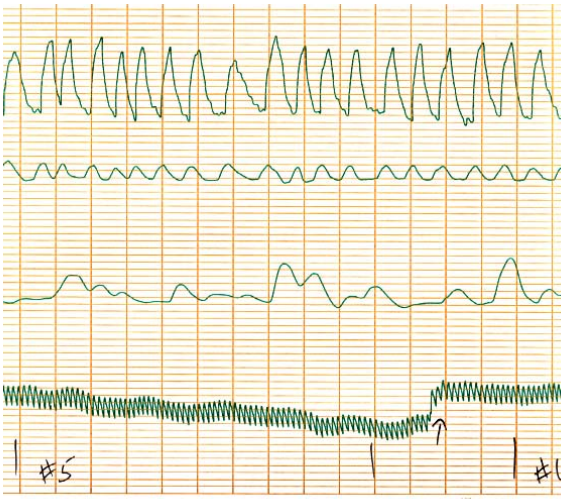
Auditory Stimulus Test # 4 Subject 6:
Stress noted heart rate, respiration rate, blood pressure, and GSR.

Auditory Stimulus Test # 4 Subject 7:
Stress noted respiration rate

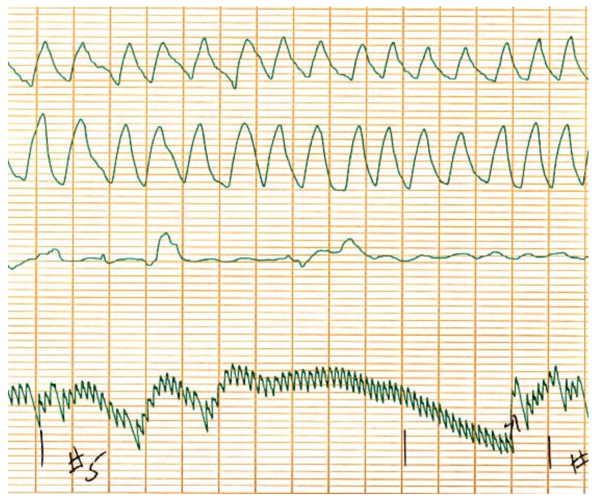


Auditory Stimulus Test # 4 Subject 8:
No stress noted.

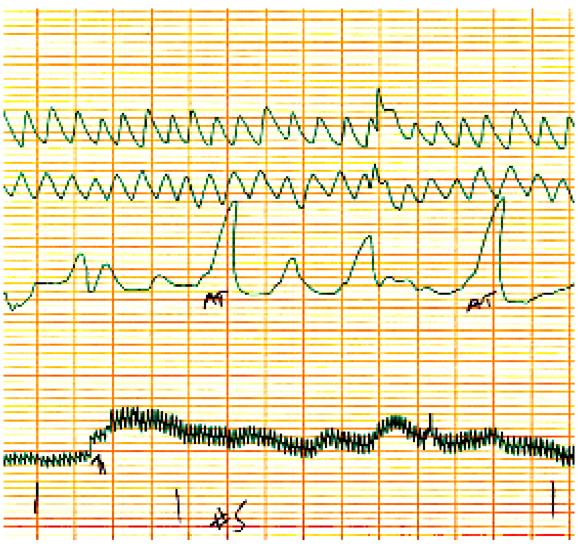
Appendix K
Physiological Event Graph Auditory Stimulus Test # 5



Auditory Stimulus Test # 5 Subject 1:
No stress noted



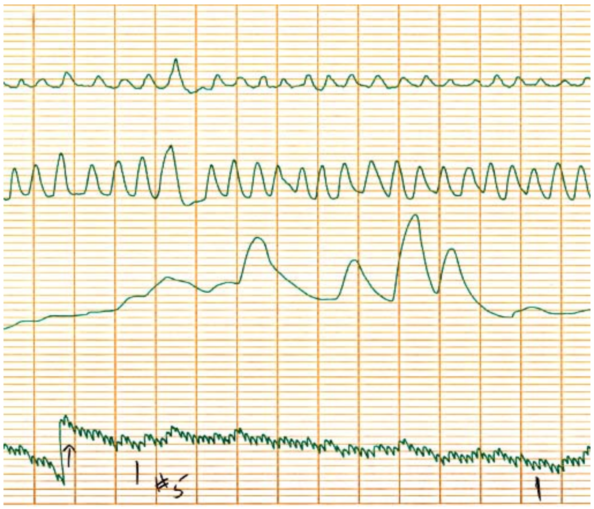
Auditory Stimulus Test # 5 Subject 2:
No stress noted.



Auditory Stimulus Test # 5 Subject 3:
No stress noted, orienting reflex to
Distress signal.

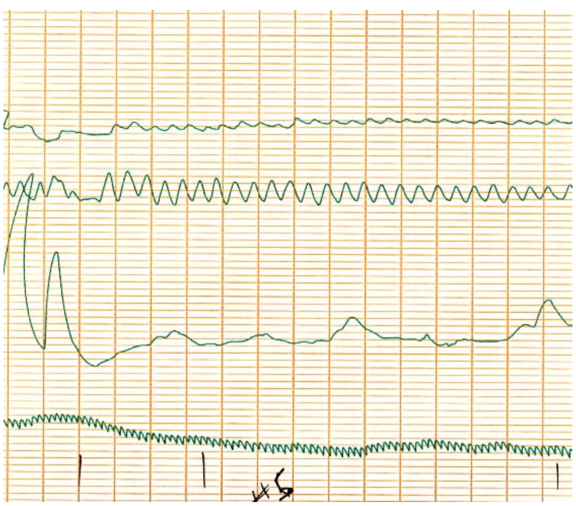
Auditory Stimulus Test # 5 Subject 4:
No stress noted.

Appendix K (Continued)
Physiological Event Auditory Stimulus Test # 5

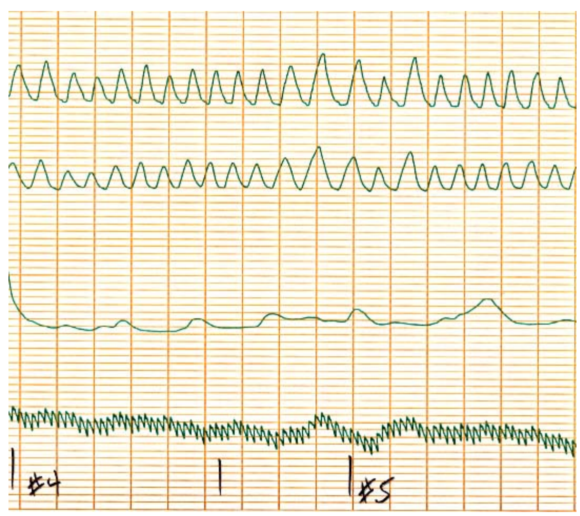


Auditory Stimulus Test # 5 Subject 5:
No stress noted.

Auditory Stimulus Test # 5 Subject 6:
Stress noted.

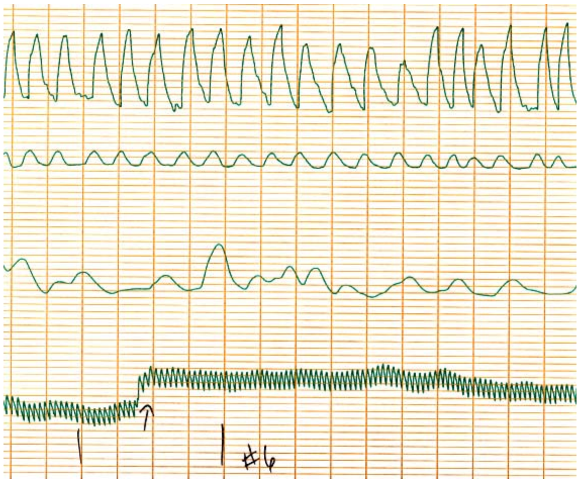


Auditory Stimulus Test # 5 Subject 7:
No stress noted.

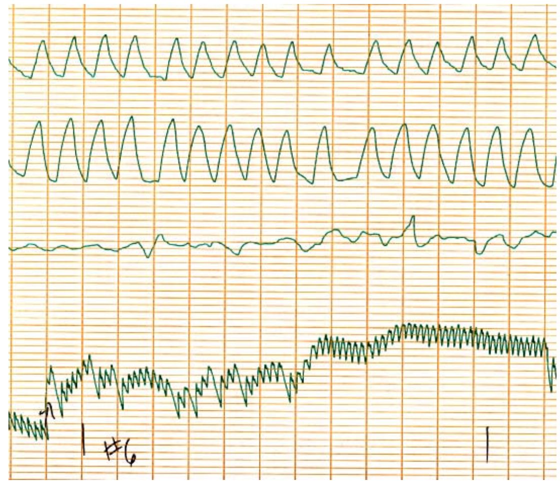


Auditory Stimulus Test # 5 Subject 8:
No stress noted.

Appendix L
Physiological Event Graph Auditory Stimulus Test # 6

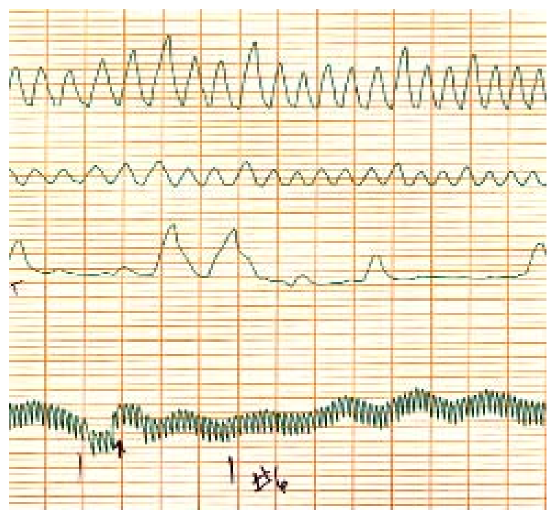


Auditory Stimulus Test # 6 Subject 1:
No stress noted



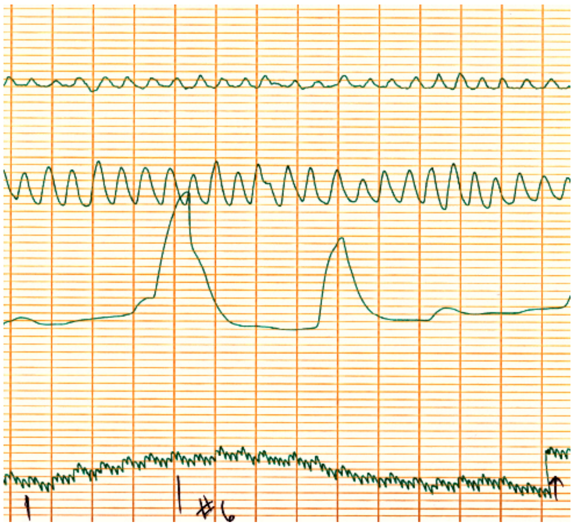
Auditory Stimulus Test # 6 Subject 2:
No stress noted.

Auditory Stimulus Test # 6 Subject 3:
No stress noted.



Auditory Stimulus Test # 6 Subject 4:
No stress noted.

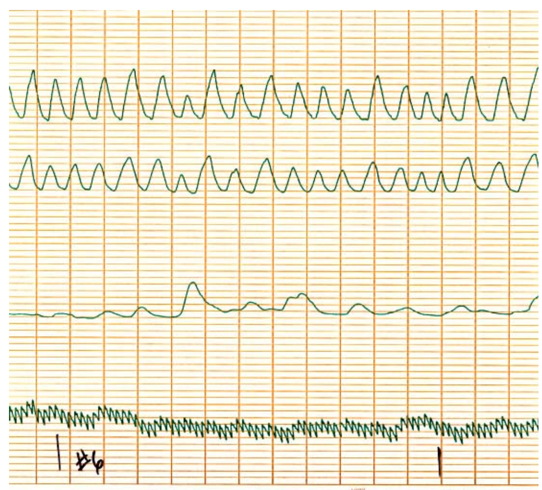
Appendix L (Continued)
Physiological Event Auditory Stimulus Test # 6



Auditory Stimulus Test # 6 Subject 5:
No stress noted.

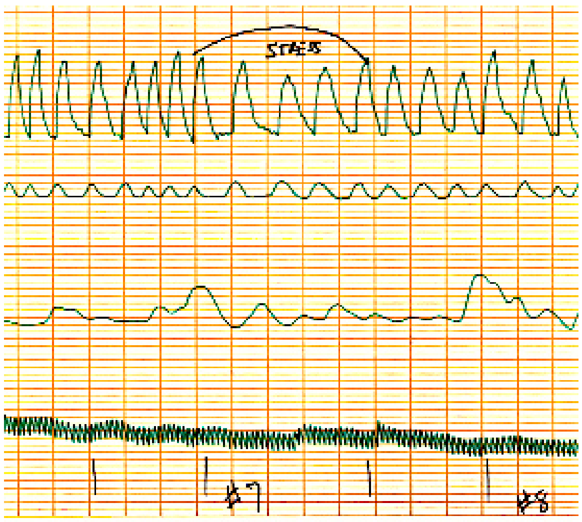
Auditory Stimulus Test # 6 Subject 6:
No stress noted.

Auditory Stimulus Test # 6 Subject 7:
No stress noted.

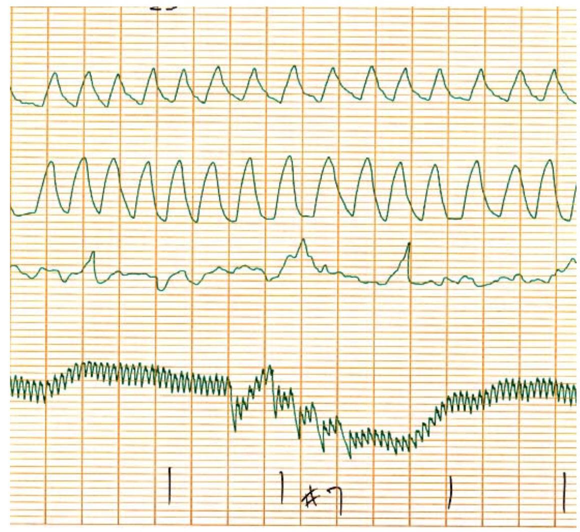


Auditory Stimulus Test # 6 Subject 8:
No stress noted.

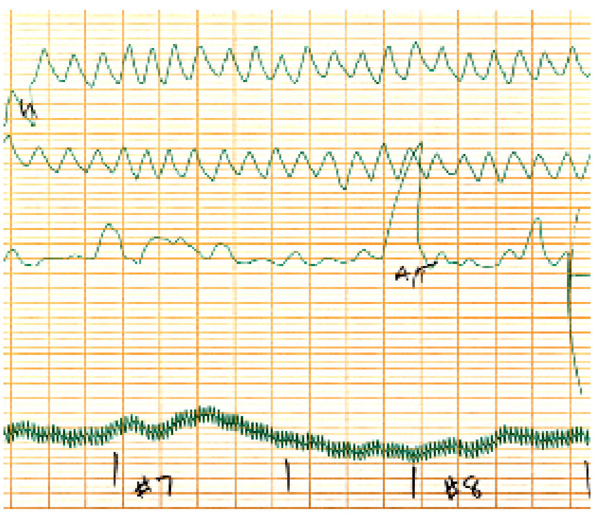
Appendix M
Physiological Event Graph Auditory Stimulus Test # 7



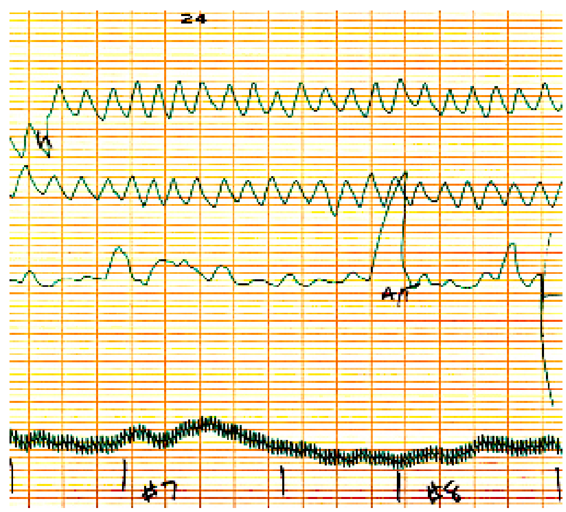
Auditory Stimulus Test # 7 Subject 1:
Stress noted in respiration rate.



Auditory Stimulus Test # 7 Subject 2:
No stress noted.

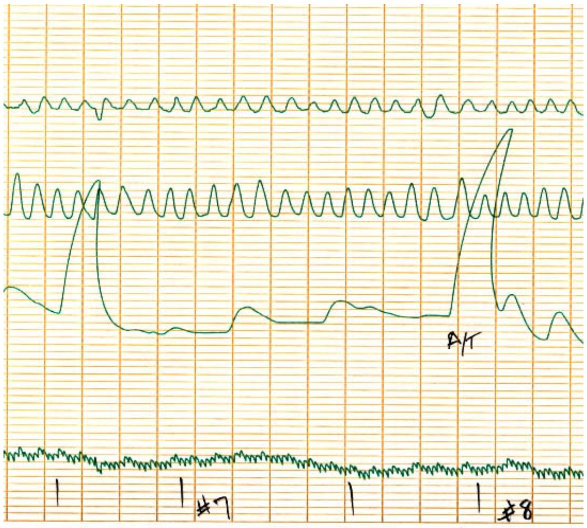


Auditory Stimulus Test # 7 Subject 3:
No stress noted.



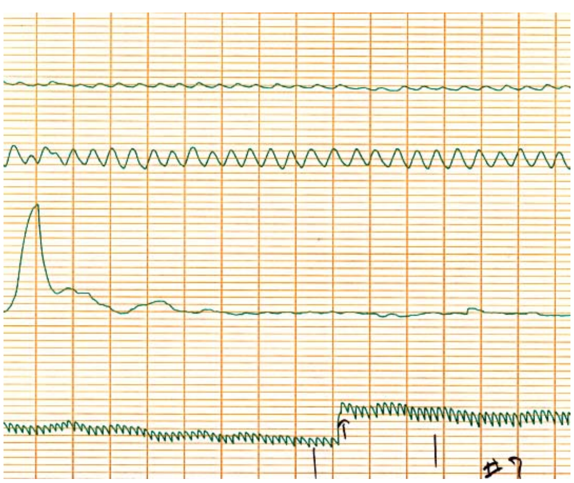
Auditory Stimulus Test # 7 Subject 4:
No stress noted.

Appendix M (Continued)
Physiological Event Auditory Stimulus Test # 7

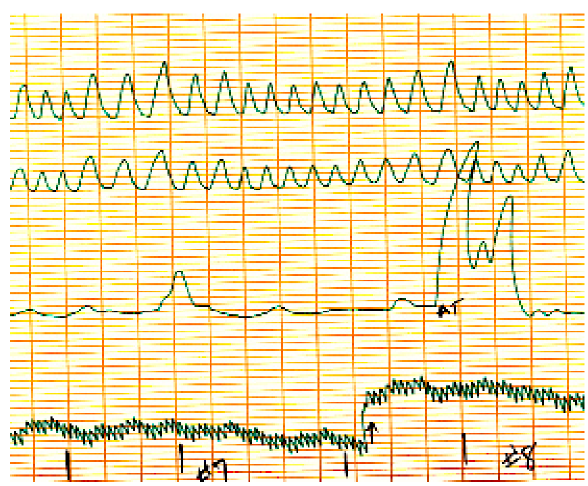


Auditory Stimulus Test # 7 Subject 5:
No stress noted, orienting reflex to the distress signal.

Auditory Stimulus Test # 7 Subject 6:
No stress noted.

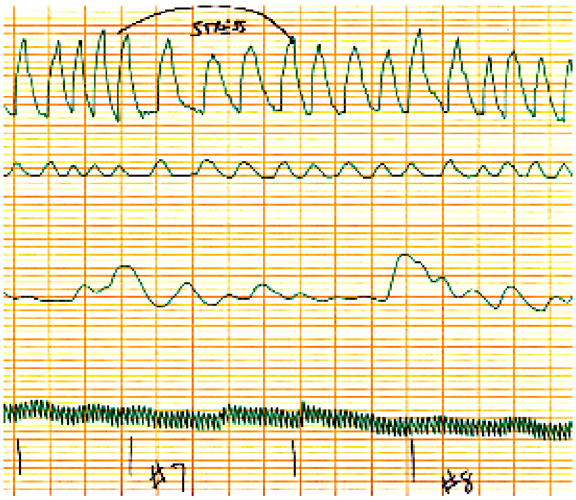


Auditory Stimulus Test # 7 Subject 7:
No stress noted.



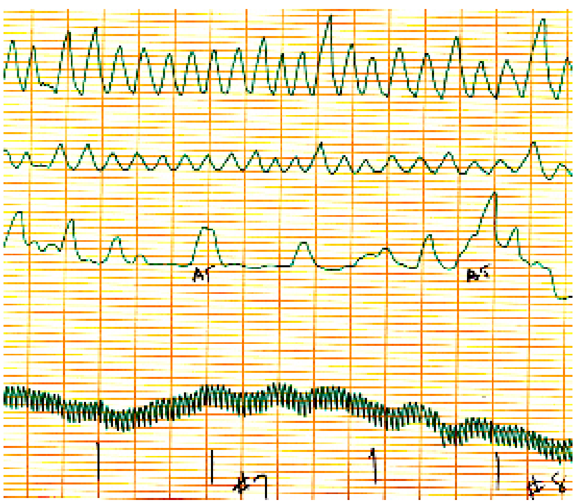
Auditory Stimulus Test # 7 Subject 8:
No stress noted, orienting reflex to the distress signal.

Appendix N
Physiological Event Graph Auditory Stimulus Test # 8

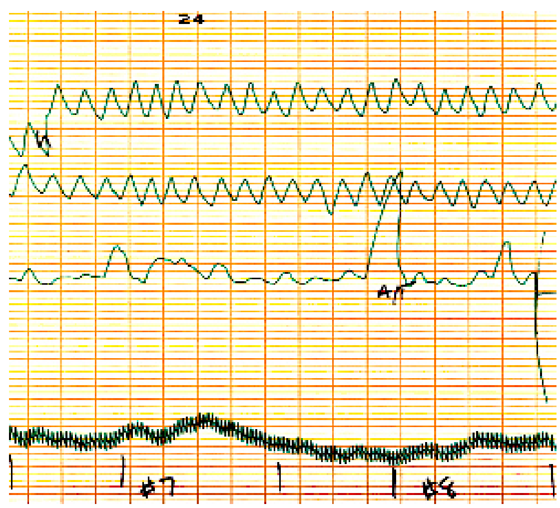


Auditory Stimulus Test # 8 Subject 1: No stress noted, orienting reflex to the distress signal (Stress is shown in Test # 7)

Auditory Stimulus Test # 8 Subject 2: No stress noted, orienting reflex to the distress signal.

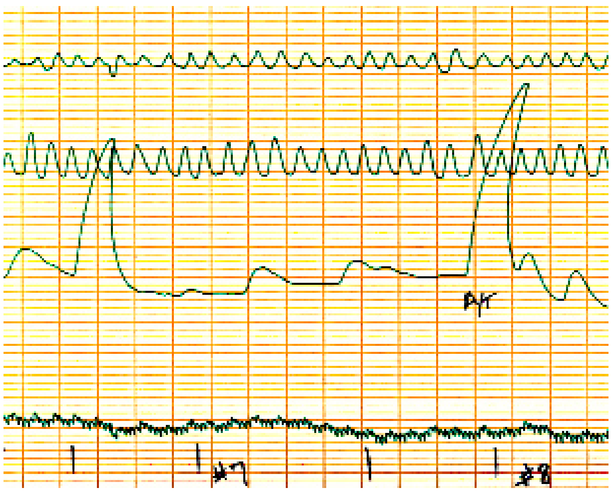


Auditory Stimulus Test # 8 Subject 3: No stress noted, orienting reflex to distress signal.

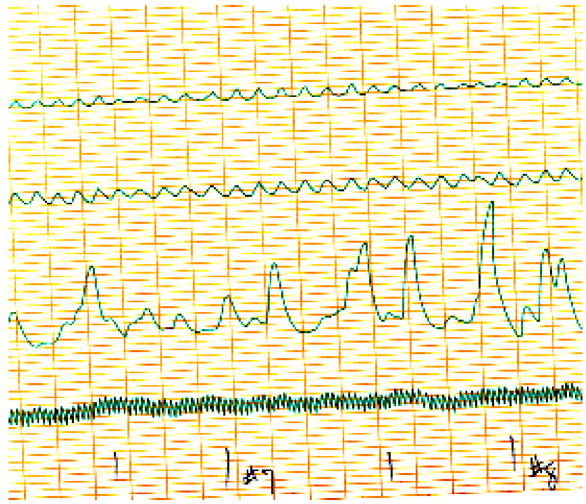


Auditory Stimulus Test # 8 Subject 4: No stress noted, orienting reflex to the distress signal.

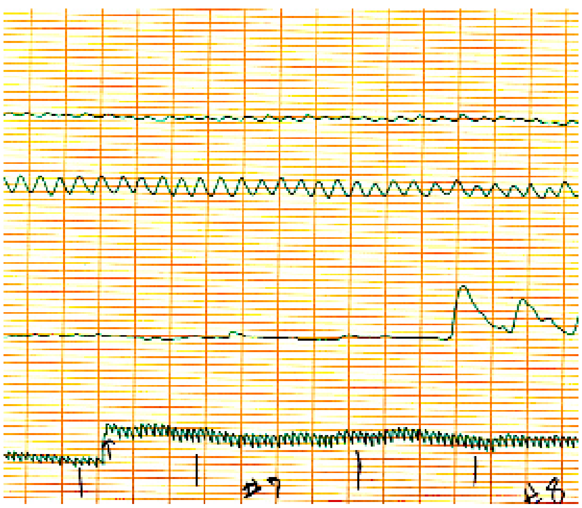
Appendix N (Continued)
Physiological Event Auditory Stimulus Test # 8



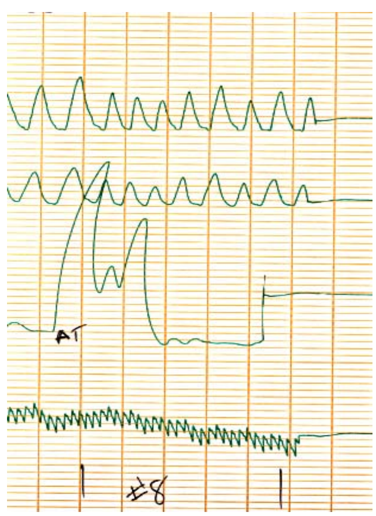
Auditory Stimulus Test # 8 Subject 5: No stress noted, orienting reflex to the distress signal.



Auditory Stimulus Test # 8 Subject 6: No stress noted.



Auditory Stimulus Test # 8 Subject 7: No stress noted, orienting reflex to the distress signal.

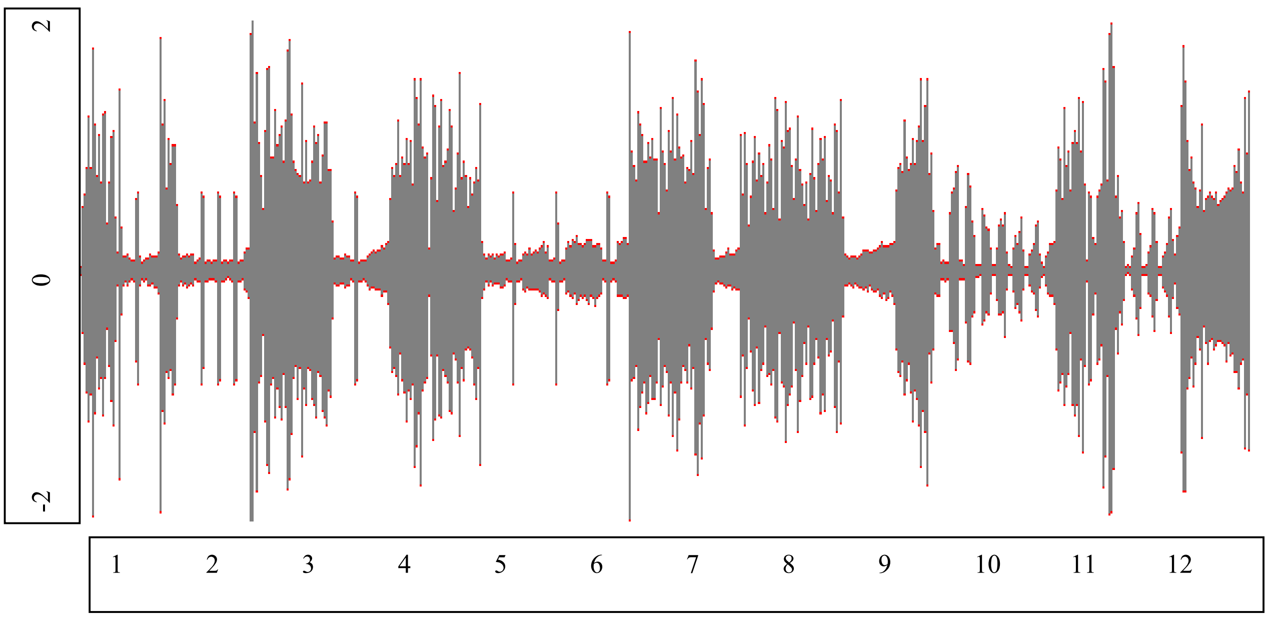


Auditory Stimulus Test # 8 Subject 8: No stress noted, orienting reflex to the distress signal.

Appendix O
Subjective Listening Tests

Visual representation of the mixture of fire ground ambience used in the Subjective Listening Auditory Stimulus Tests.

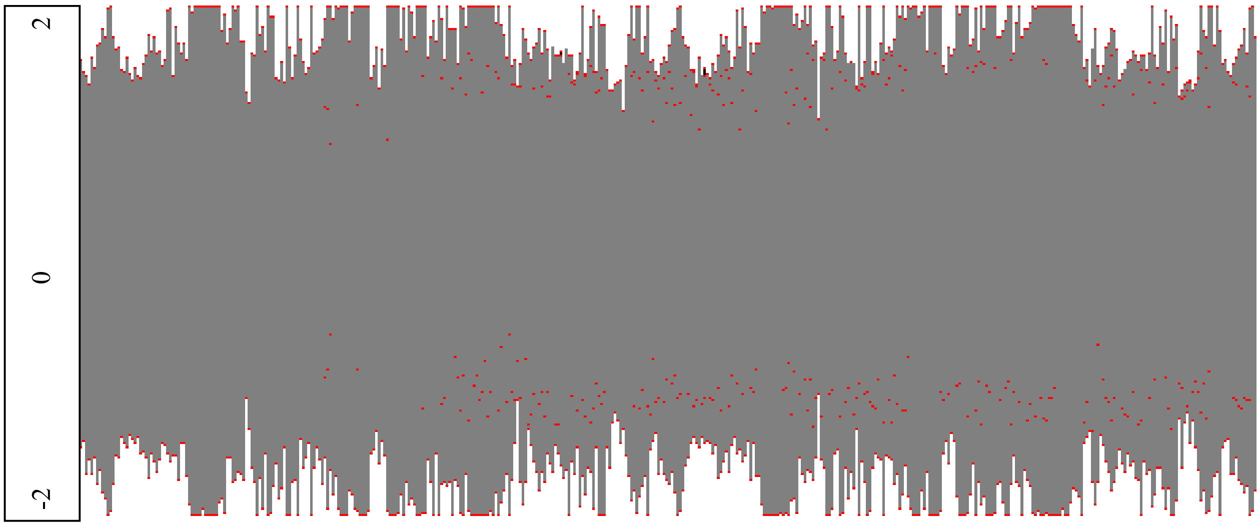
Auditory Stimulus Test # 1--Waveform of fire ground ambience of heavy fire inside a structure and the operation changing to a defensive mode with Command requesting for a PAR (personal accountability report) and the pre-alert sounds of a PASS device.



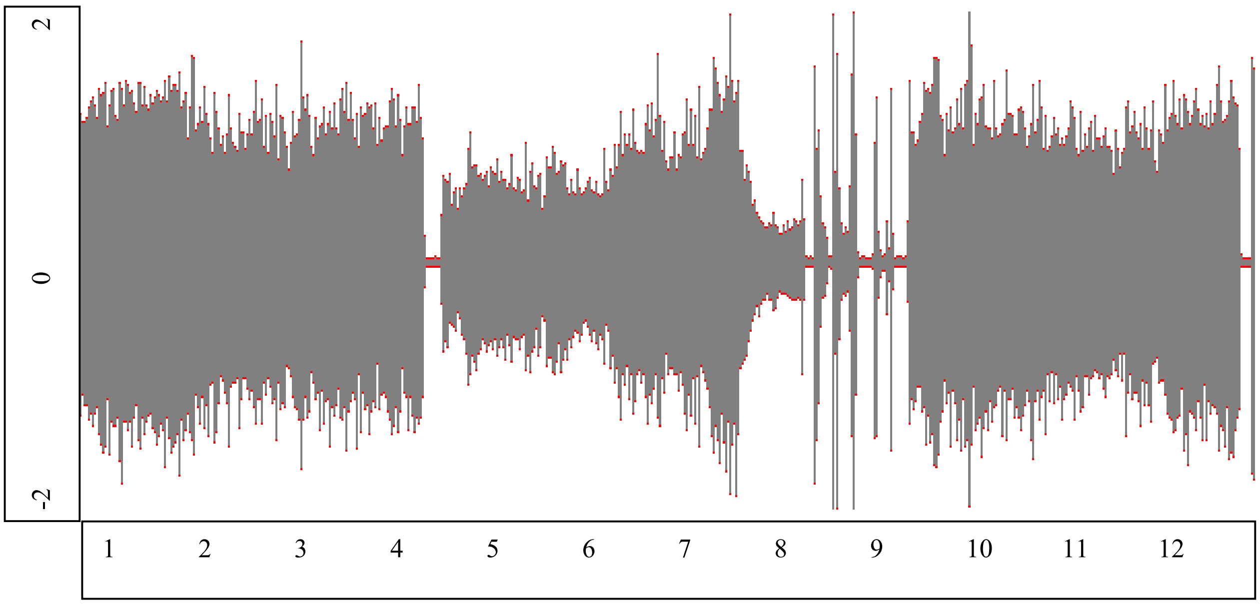
Note: The above waveform of auditory stimulus is a mixture of all the fire ground ambience and distinctive sounds. The multiple signals and waves are difficult to distinguish in the time-frequency form. Therefore, the speech waveform, as well as the other waveforms were separated out individually without any background noise and listed below. When the waveform is separated out from the background noise the amplitude appears larger than when mixed with other fire ground ambience.

Appendix O (Continued)

Auditory Stimulus Test # 2--Waveform of engine noise from a fire apparatus changing pitch as the RPM increases because of flowing water.

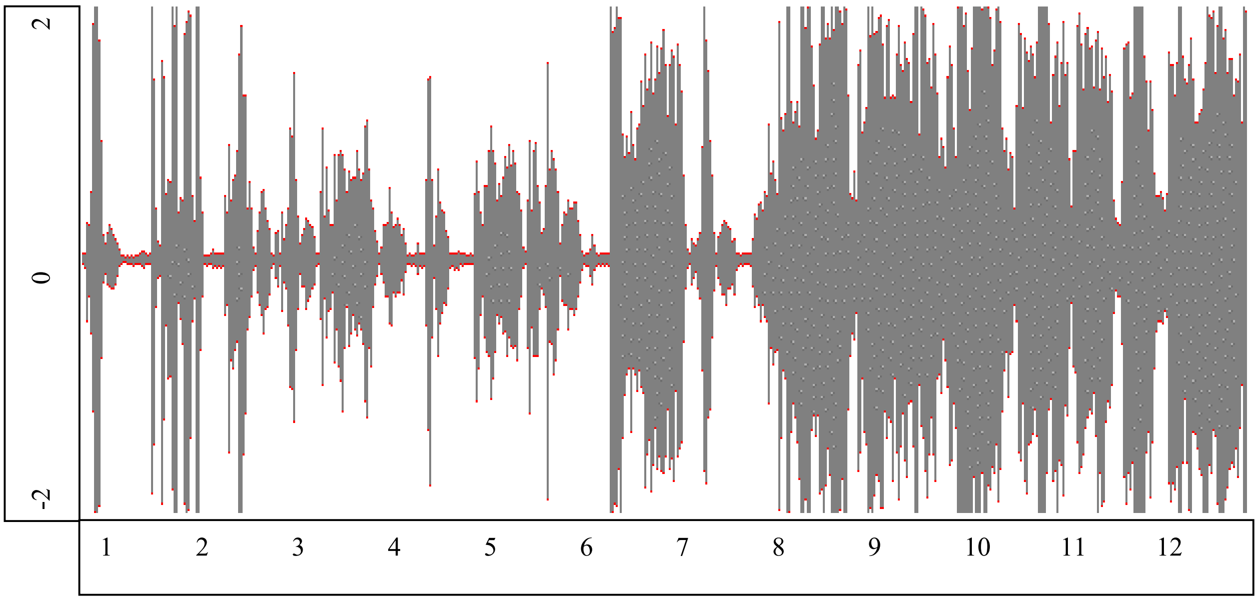


Auditory Stimulus Test # 3--Waveform of engine noise from a positive pressure fan as the engine stalls and then is re-cranked.

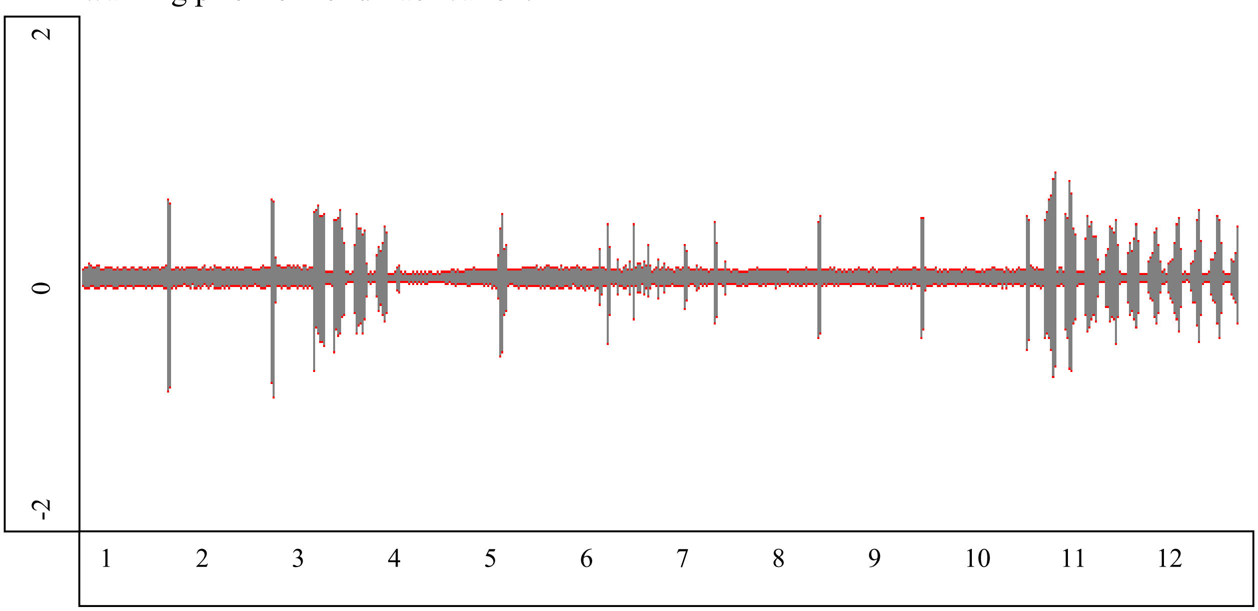


Appendix O (Continued)

Auditory Stimulus Test # 4--Waveform of an anxious mother stating her baby was still inside the structure.

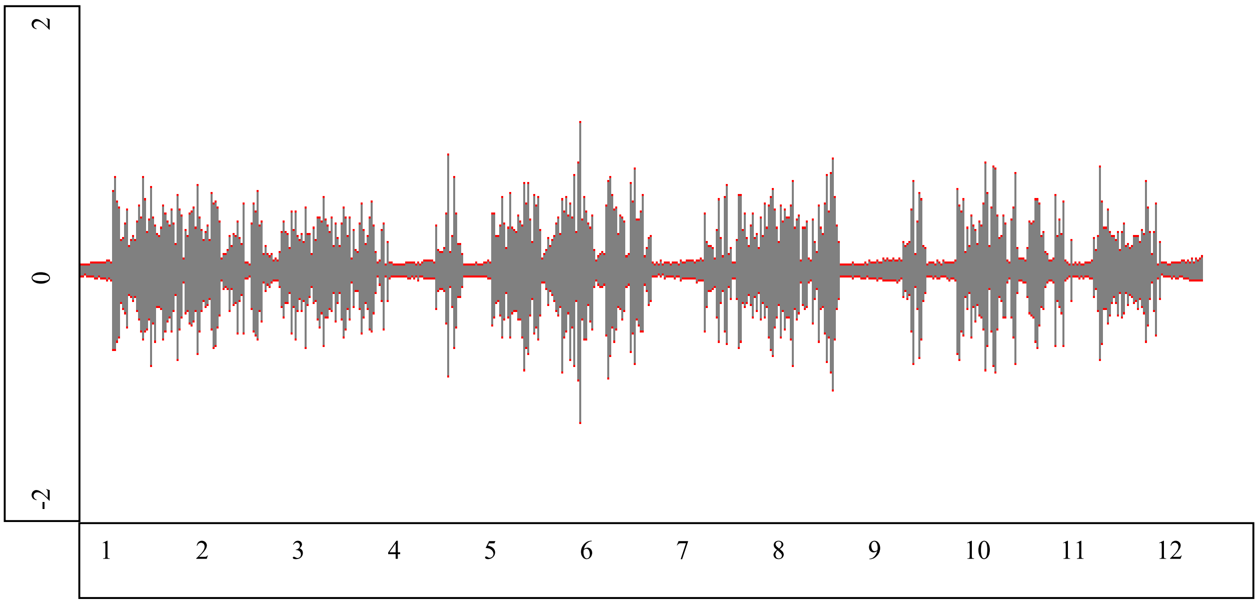


Auditory Stimulus Test # 5--Waveform of the pre-alert tone of a PASS device and the 10 second warning prior to the full activation.

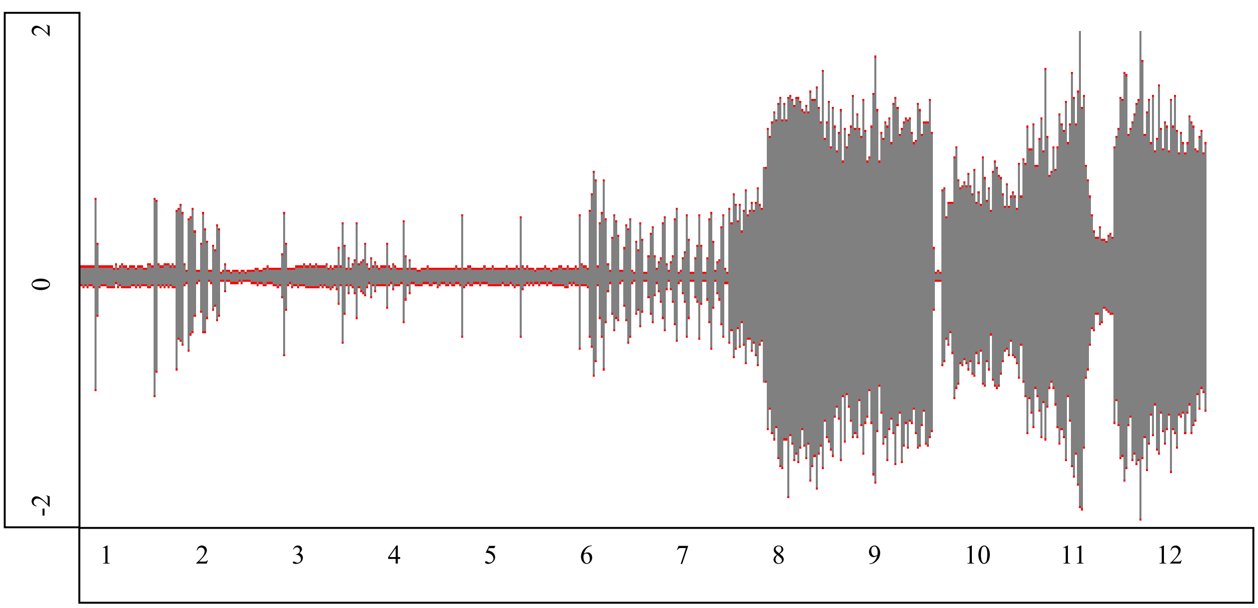


Appendix O (Continued)

Auditory Stimulus Test # 6--Waveform of Command acknowledgement of heavy fire on Side 3.



Auditory Stimulus Test # 7--Waveform of a full activation of a distress tone from a PASS device from a distance.



Appendix O (Continued)

Auditory Stimulus Test # 8--Waveform of the full activation of a distress tone from a PASS device.