



# Experimental study on physiological changes of people trapped in coal mine accidents



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## ABSTRACT

The research targets to obtain the extent of the physiological changes of the victims of accidents. During the research, the physiological indexes of the volunteers were first measured both before and after the experiment for which the coal mine accidents are simulated; next, the extent of the variations and the significant differences of the indexes are analyzed. The results indicate that the victims of the accident have experienced intense physiological and psychological changes. These significant physiological and psychological changes include: systolic blood pressure, mean pressure, pulse rate, pulse pressure, heart rate, R–R interval, R wave amplitude respiratory rate. The one that has gone through the most significant variation is the pulse pressure. However, only the systolic blood pressure and the heart rate have demonstrated significant change during the second trial. Practical Applications: The psychological changes of the victims are rather rapid and complex. The victims' abilities for carrying out proper judgments and actions that accord with the surrounding were weakened by their physiological state. It is of significance to quantitatively analyze physiological variation of the victims, to select the staffs through the personality assessment and to improve individual's psychological quality and the ability of emergency disposal by training in the simulated accident scenarios.

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## 1. Introduction

Disasters or accidents are unexpected events that occur during production or in one's life. For a long time, frequent natural disasters and accidents during work worldwide, have not only caused tremendous casualty, property losses, but have also negatively affected the economic development and social stability, as well caused physiological and psychological trauma to human being. United Nations International Strategy for Disaster Reduction (UNISDR) defined the disaster as a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources (UNISDR, 2009). In the late 1950s, The University of Chicago conducted a large extent of research in disaster psychology for which the representative among them is Moore H. and Frita C. Abundant amount of information and data were accumulated on the topic of individual reaction, victims of the

mass reaction and the mental health. In the 1960s, American Disaster Research Center in the Ohio University where the social psychologists Dynes R. and Quarantelli E. were the leaders also conducted a great deal of research in the field of disaster psychology, group organization, role adjustment, evacuation behavior, disaster relief morale, disaster relief decision and so on (Hu, 1993).

Psychological stress is one of the influences that the disasters and accidents bring, and it has the potential to affect safety. People when encountering disaster or accident will experience psychological stress, behaviors include different degrees of mood changes, psychological reaction, cognitive impairment, abnormal behavior and so on (Zhang et al., 2010). Individual's psychological and physiological systems are interrelated and are mutually influenced. If one is in poor physiological condition, his or her psychological condition will be affected. On the other hand, a poor mental state largely tends to cause physiological system disorders. Moreover, external environment affects the whole state of psychological and physiological system, which eventually affects the behaviors and the operations (Li, 2007). Disasters and accidents cause stress for individuals, which subsequently induce physiological and mental health damage, which may weaken the work efficiency and enhance the chances of accidents.

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A great deal of research has proved that the stress can influence human beings physiologically. The human response to stress is an important mechanism to cope with real or anticipated threat. It influences one's endocrinology, physiology, cognition and behavior (Duchesne et al., 2012). The neuroendocrine stress response has been identified as an important biomarker of susceptibilities to various diseases and is associated with differential disease progression (DeRijk and de Kloet, 2008). Psychological stress can cause one's physiological changes. For example, when people are intimidated, systolic blood pressure will rise and this reaction is similar to the one after injecting epinephrine into human body. When confronting with emergencies, or emotional situations, people's autonomic nervous system will subject to change, which will then lead to significant changes in heart rate, blood pressure, and so on (Zhang et al., 2007). Acute stress elicits metabolically exaggerated in cardiac activity, and the cardiac activity induced by acute stress is more intensive than induced by the physiological activity. Also, more exaggerated cardiac reactions result in greater  $\beta$ -adrenergic activation (Balanos et al., 2010). Sympathetic nervous activity plays a prominent role in acute stress responses in the immune system, and that is the sympathetic cancer cells grow in its quantity under the affect of acute stress. Cardiovascular activity and the variations of immune indices are related to the acute stress as well, this was proved in the experiment (Kimura et al., 2005).

Meanwhile, it has been confirmed by the researches in different field that the stress can cause human diseases. When people are under the high stress condition, the psychological crisis can reach 43.3%, which is twice the possibility an ordinary person can reach if there is a lack of assistance and appropriate coping style (Dong et al., 2006). Studies on military personnel, such as Vietnam veterans, navy personnel, veteran officers from unarmed UN military and submarine crew, have shown that traumatic events are associated with physiological health problems and the development of post-traumatic stress disorder (PTSD), as well as depression and anxiety disorders, hyper arousal, disturbances in attention, and increase in risk behaviors (higher alcohol consumption levels) (Hourani et al., 2003; Mehlum et al., 2006; Pawar and Rathod, 2007; Magerøy et al., 2008; Shucard et al., 2008; Baert et al., 2011). Post-traumatic stress symptoms and PTSD have been recognized among physicians, nurses, rescue and ambulance workers, in critical care also regularly deal with dying patients (Alexander and Klein, 2001; Jonsson et al., 2003; de Boer et al., 2011; Adriaenssens et al., 2012). Traffic accidents cause health problem to drivers in public transportation, such as musculoskeletal disorders, anxiety and depression (Vatshelle and Moen, 1997; Yuma et al., 2006; Clarner et al., 2015). The majority of the victims of sports diving accidents suffered post-trauma difficulties 3 months after the accident and between 25% and 50% continued to suffer in 12 months (Trevett et al., 2010). The psychological effects of the Chernobyl disaster lasted a long period after the accident. Recent studies show that their rates of depression and PTSD remain elevated two decades later. Across disasters, the risk factors that increase the likelihood of mental health consequences are the severity of the disaster, the post-disaster circumstances and personal vulnerabilities (Bromet et al., 2011). People who suffer from hurricane will experience various extents of abnormal psychology and behavior. PTSD symptoms fear reactivity, regulatory abilities, and social experiences, are relevant with the extent of the trauma (Terranova et al., 2009).

Many scholars using different methods and experimental indexes studied the relationship among human physiology, psychological stress, and the source of stress. For example, through the two stress conditions, simulated emergency situation and laboratory stress, the trial subjects' salivary cortisol and other physiological indexes were measured to analysis the level of

physiological stress. The result proves the simulated emergency situation to be a profound source of stress, which can cause the stress progress of the people (Keitel et al., 2011). Through the simulation of the combination of night-shift work and noise, the trial subjects' measured physiological indexes such as urinary catecholamines, electrodermal activity, heart rate, ratings of mood and so on reflected the changes of autonomic reactions, reaction times, and ratings of subjective alertness that are typical for night-shift work (Boucseina and Ottmannb, 1996). According to the experimental data, the qualitative and quantitative level of fatigue is determined through researching change law of fatigued labor employees' physiological parameters (Meng et al., 2014).

Among all industries, the coal mine is universally acknowledged to be one of the most hazardous one (Amponsah-Tawiah et al., 2013; Gyekye, 2003). The hazardous nature of coal mine operations can easily be deduced from the national statistics of mine accidents and injuries (Paul, 2009). The production of coal mine poses many risks, which may potentially cause detrimental effects on workers in the form of injury, disability or fatality. Additionally, mining company may even go bankrupt or suffer great loss because of the accident (Mahdevari et al., 2014). Via multiply aspects of questionnaires, a research was conducted for interrelationship among the physiological, psychological conditions, life style, and level of tiredness of the miners in Australia. The research results demonstrated that a majority of miners experience body pain. This is related to the sleep quality and psychological stress. Moreover, the pain affects the efficiency and behavior of workers at workplace (Carlisle and Parker, 2014). The current research on the coal mine predominantly focuses on the analysis of the causes of accidents and ways of preventing them through engineering and technical means. Far less attention is paid to the analysis of miners' physiological and psychological harm after the accidents. Therefore, the authors, by using the simulated accident scene of coal mine, simulated accidents among the volunteers, and performed statistical analysis of physiological indexes before and after the accident. The result has shown significant differences of the physiological indexes before and after the experiment. The paper will thus address the extent and interrelation of the physiological and psychological change of the victims who are trapped by accidents.

## 2. Methods

Mine accidents include methane (coal dust) explosion, combustion, coal and gas outburst, roof accident, colliery flood, electromechanical accidents, fire accident and so on. In this research paper, with the safety of the volunteers are secured, gas explosion, roof accident and fire accident are simulated. Subsequently, the physiological indexes of the volunteers were measured and analyzed before and after the experiment.

### 2.1. Design of the accidental scene

The sudden accident scenes in coal mine were simulated via the suppositional experimental system, which combined the visual and physiological sudden accidents scene.

#### (1) The simulated gas explosion accident

The simulated experiment was conducted at perfect timing that allowed the explosion sound to be played by audio right at the moment the pre-set gas explosion accident's 3D video was played. Under this effect, the volunteer felt as if he/she indeed experiences in the real gas explosion accident (see Fig. 1).

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