Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 23-24, 2019

An Experimental Study on the Impact of Fundamental Surprise on Human Performance: Research Design

Sa Kil Kim*, Joo Hyun Sim, Yong Hee Lee
Nuclear ICT Research Division, Korea Atomic Energy Research Institute, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, 305-353, Republic of Korea
** Corresponding author: Tel. +82-42-868-4755, Fax. +82-42-868-8916, E-mail sakilkim@kaeri.re.kr*

1. Introduction

Since the Fukushima Daiichi accident in the nuclear power industry, it has become an important issue to improve the operator's ability to respond to unknown unknowns. The unknown unknowns that can arise in natural disasters such as earthquakes and tsunamis cause fundamental surprises for operators. The fundamental surprise has been studied for a long time in terms of human error through psychological or human factors approach to human behavior. However, few studies have quantified the effects of fundamental surprise on human performance cause of ambiguous definitions of the fundamental surprise. The purpose of this study is to experimentally quantify the effect of fundamental surprises caused by earthquakes on human performance in the control room of a nuclear power plant. This paper introduces experimental research methods and results.

The term ‘fundamental surprise’ was coined by Zvi Lanir [3]. The fundamental surprise was also used for explaining the TMI-2, Chernobyl, and Fukushima Daiichi accidents. A fundamental surprise reveals a profound discrepancy between one’s perception of the world and the reality [4].

As shown in Figure 1, the basic assumption led the stakeholders to believe an accident of this kind would not happen and resulted in their conscious and unconscious rejection of the importance of certain knowledge elements and undermining the importance of sharing and combining them [2].

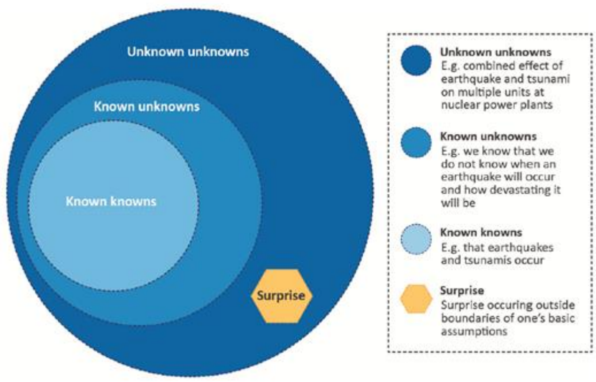

Figure 1. The impact of unknown unknowns (IAEA, 2015)

Also automation surprise in aviation continue to be a significant concern and many researches for effective strategies to mitigate them are ongoing [5]. The automation surprise can be classified as a kind of fundamental surprise. A fundamental surprise can occur in unknown unknowns. In those unknown unknowns, human behavior expected in the context is, in a word, unpredictable. As see the Figure 2, the fundamental surprise can occur by relevance gap in a perceptual process. Zvi Lanir suggested that the fundamental surprise error is to avoid any fundamental meaning and to learn the situational lessons from the surface events.

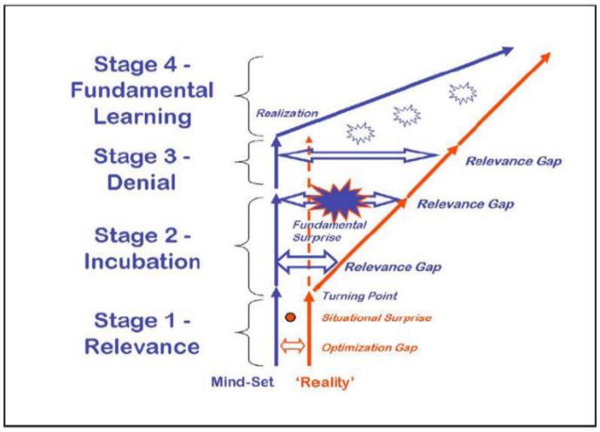

Figure 2. 3 Stages of Fundamental Surprise (Zvi Lanir, 1986)

2. A Conceptual Model of Surprise

In order to explain the causes and effects of surprise, the conceptual model of startle and surprise is useful (see Figure 3). In the perceptual cycle, hypotheses based on the active frame are continually applied and tested with regard to their practical consequence [1].

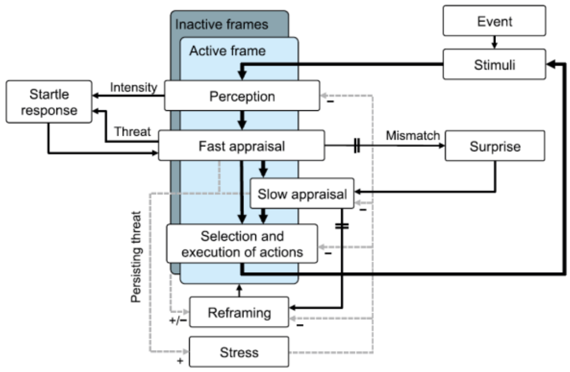

Figure 3. Conceptual model of startle and surprise (Annemarie, et al., 2017)

3. Human Performance in Fundamental Surprise

On March 31, 1993, a severe fire accident took place in a nuclear power plant located in Narora in North India. The event involved a major fire in the turbine building of NAPS unit-1 and resulted in a total loss of power to the unit for 17 hours. In addition, there was a heavy ingress of smoke in the control room, mainly through the intake of the ventilation system, forcing the operators to vacate the control room. The Narora fire accident provides us lessons indicating that operators could lose their mind and predictable behaviors during a fire.

After the Fukushima accident, which resulted from a natural disaster, unanticipated external events are also required to be prepared and controlled for the ultimate safety of nuclear power plants. Our research team has developed a test and evaluation facility that can simulate external events such as an earthquake and fire based on the operators' real-sense. As one of the results of the project, we proposed a unit real-sense-based facility that can simulate fire events in a control room for utilizing a test-bed of human factor validation. The test-bed has the operator's workstation shape and functions to simulate fire and/or earthquake conditions such as smoke, heat, vibration and auditory alarms in accordance with the prepared scenarios.

There are three main aspects of the operators' real-sensing factor that should be considered in the human factors verification and validation of nuclear power plant control room. First, when the operators monitor or control the status of the equipment in the field as a realistic element, the state is simply the information of the text, symbol, mimic diagram, etc. It is possible to increase the level of real-sense through 3D interfaces which can be improved. Secondly, 3D visualization technology which allows the operator to realize the macroscopic condition of the nuclear power plant immediately before or after core-melting can be increase as an actual real-sensing factor of the emergency condition or severe accident. Lastly, there is a way to increase the level of real-sense against the external event by realizing sensation in the control room due to earthquake or fire, physically realizing high temperature, toxic gas and smoke due to fire.

In this study, we focus on a fundamental surprise caused by earthquake in main control room of nuclear power plant. Using the real-sense based test-bed, we produce fundamental surprise situation accordance with the conceptual model by Ammemarie et al. Also, we have a plan to measure the quantitative human performance in terms of bio-signals in a situation of fundamental surprise.

4. Conclusions

In the nuclear industry, human factors verification and validation is a systematic method of verifying and validating whether the developed human system interfaces are appropriate in terms of human performance. However, there was a limit to systematically incorporating changes in the expected control room environment due to external events such as earthquakes and fires into the human factors verification and validation process.

Changes in the control room environment can cause unexpected surprise to the operator, which can significantly reduce human performance. Therefore, this study aims to clarify the quantitative effects of unexpected surprise of the operator on the performance and to provide a way to minimize the human error caused by fundamental surprise.

In this paper, quantitative effects of unexpected surprise on human performance are introduced in the course of experimental research and experimental methodology. The results will be discussed in detail at the next conference.

ACKNOWLEDGEMENTS

This work, described herein, is being performed for "Development and Operation of ICT-based Nuclear Energy Safety Validation System" as a part of the Korea Atomic Energy Research Institute (KAERI) projects and funded by Ministry of Science and ICT since on January the 1st, 2018.

REFERENCES

[1] Annemarie, L., et al. (2017), Dealing with unexpected events on the flight deck: A conceptual model of startle and surprise, Human Factors, Vol. 59, No. 8, pp.1161-1172.
[2] IAEA (2015), The Fukushima Daiichi Accident.
[3] Lanir, Z. (1983), Fundamental Surprises, Center for Strategic Studies, Tel Aviv.
[4] Reason, J. (1990), Human Error, Cambridge University Press, New York.
[5] Robert D. B. and Sidney D. (2017), Models of automation surprise: Results of field survey in aviation, Safety, Vol. 3, No. 20.