Development of operational task to measure working memory as a human factor

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1. Introduction

The mission of the nuclear MCR consists of various tasks that require cognitive resources. The limitations of cognitive resources can affect situational awareness and decision making of operators. It can also affect the ability of the operator to perform tasks in the main control room and to respond to events. Cognitive resources affect not only situational awareness and decision making but also the performance of prescribed procedures because working memory involves the performance of procedure-based behaviors. Especially in extreme situations, such as fire or earthquakes, cognitive capacity may be further reduced, and knowledge-based behaviors of operators may become difficult.

Therefore, the workload of the MCR operator should be considered as an important factor in safety. High workloads can lead to accidents caused by human errors. Workload refers to the amount of resources required to perform a specific task among the limited processing capacity of the operator [1]. The greater the mental workload, the more cognitive resources are consumed. If the mental workload exceeds the limit of the worker, human error may be induced and performance may be degraded [2].

Two approaches can be used to solve problems associated with workloads. One is to train the working memory of individuals, and another is to support cognitive performance using the system (e.g., display). Both approaches require the method to measure the workload.

2. Measure of Workload

The existing method to measure mental workload can be divided into subjective measurement method, performance evaluation method, and physiological measurement method [3]. The subjective measurement has the disadvantage that memorization can be distorted in the post evaluation, and the interruptive questionnaire technique requires the simulation to be stopped during the execution of the experimental scenario.

For example, the freeze probe technique, such as SAGAT which measures situation awareness [3] need to freeze the task simulation. Therefore, intrusions can occur in the task performance of the operator, and there are difficulties associated with applying this technique in the real world. In addition, responses may be exaggeratedly generalized or rationalized in the case of self-questionnaires.

Performance-based measure is a method of evaluating workload by measuring performance or error of worker. Performance-based measure is based on the assumption that there is limited processing capacity for humans and that some of the limited resources are used for task performance [2]. Thus, if the operator experiences a workload exceeding the limit, the operator may make a mistake or decrease the performance.

The disadvantage of the performance-based measures is that it is also intrusive in the performance of the workers because it requires control of the experimental situation for evaluation. However, because the performance-based measure is a quantitative method for analyzing the performed tasks, it seems to be able to secure objectivity rather than the subjective measurement method.

Therefore, if the disadvantage of intrusion or distortion of these existing measures can be minimized, the advantage of the performance-based measures can be maximized. In this study, we develop a new workload measurement task that can overcome these drawbacks. Then, it can be used as a task to be used as a new design effectiveness test or training task in the MCR.

3. Working Memory Task

Working memory is a factor that directly affects cognitive resource capacity and is used for perception of information and utilization of existing knowledge. Working memory plays a key role in various cognitive tasks. If the amount of information to be processed exceeds the range of the working memory, it can be said that the workload is increased. Therefore, the working

memory measurement can be used as a method of measuring the workload.

Traditional working memory tasks include operation span task or forward / backward digit task, etc. In addition to verbal working memory tasks, various tasks such as mental rotation, and BOMAT task have been used as visuo-spatial working memory task. The working memory task such as the forward digit span task, can measure simple memory retention. Or it can be applied as a complex task by adding operational tasks such as math calculations to simple memory retention. In other words, it can be applied to measure working memory while performing operational tasks that require decision making.

The working memory task is a quantitative method for measuring performance that can complement the disadvantages of subjective measurement method which post trial recall process causes distortion. Furthermore, the working memory task can be embedded with a process of the simulation task to minimize the disadvantage of intrusion of existing measurements. This makes it possible to apply the WM task as a method of real-time measurement without interrupting simulation or manipulating experimental conditions.

In this study, we propose a method of inserting a working memory task as a part of a simulation task with numerical values representing the current state of the nuclear power plant.

4. Conclusion

This study examines how to apply the working memory task to operational task for the MCR. That is, we develop a method to measure working memory related to tasks or numerical values in the MCR while processing operational tasks. In this way, it is possible to compensate for the disadvantage of the intrusive method which needs to be executed by controlling the experimental situation of the existing performance-based measures. We expect that it can be used as one of the performance evaluation methods in MCR.

REFERENCES

[1] R. O'Donnel, F.T. Eggemeier, Workload assessment methodology, Handbook of perception and human performance, 1986
[2] D.A. Norman, D.G. Bobrow, On data-limited and resource-limited processes, Cognitive Psychology, Vol 7, pp44-64, 1975.
[3] M.R. Endsley, Toward a theory of situation awareness in dynamic systems, Human Factor, Vol 37, pp.32-64, 1995.