Development of Interactive Educational Program about Human Error

JR East has developed educational programs covering human errors for railway personnel. To help learners understand that anyone can make an error, each program includes a serious game to give them a chance to experience their own errors. This paper focuses on the elaboration of these serious games. We examined impacts of factors related to the setting of the games in order to make certain that learners make errors in the game. The results showed that the error rate is considerably high in the serious games of the program for learning mistakes. As for the other programs, indications show that development of programs based on the findings in the experiments will promote participants’ comprehension about human errors and their motivation to prevent these errors.

Keywords: Human factor, Human error, Learning material, Serious game

1 Introduction

The decrease in the number of accidents and progress of computerization in recent years has been reducing opportunities for personnel experience failures. In such circumstances, personnel might gain the wrong idea that they will not make errors. Such incorrect perception will not raise their motivation to prevent accidents due to human errors.

In this research, we developed programs that allow personnel to learn and experience on PCs at their workplaces that anyone can make errors, even in simple tasks. These educational programs aim to make learners deeply involved with the learning process by making them think and action for themselves. It is said that such an experiential program better facilitates learners in applying lessons to their own issues than a traditional knowledge-providing program does. We aimed for the developed programs to provide personnel with an understanding of the mechanism by which errors occur and inducing factors of errors and encourage them to formulate countermeasures for themselves.

2 Structure of the Programs

The errors to be educated on were selected with emphasis placed on those for which education is critical, based on analysis results of accidents and incidents that occurred at JR East in the past three years. Out of those, we decided in this research to deal with errors due to assumptions, errors due to careless decisions, communication errors, and errors due to violation of rules. In total, we developed five programs. The goals of those programs were to make learners feel human errors are relevant to themselves and obtain knowledge of those errors. To achieve those goals, individual programs consist of two parts. The first part is a game with which learners experience human errors to be educated on. A game that provides learners with a lesson like in this part is called a serious game, and such games for safety education have been developed in recent years (Haga, Onodera, Yamakawa, Oishi, Takeda, and Kusukami, 2013; Tesei, Barbieri, and Kessel, 2012). The second part is a commentary on errors. The structure of this part is common amongst all five programs as 1) review of the error experienced in the game, 2) introduction of cases of accidents caused due to errors by job category, 3) detailed explanation of the mechanisms of errors, and 4) introduction of countermeasure examples.

3 Details of the Programs

This chapter introduces details of the programs, focusing on their game parts.

3.1 Error Due to Assumption

An error due to assumption occurs in a situation where a person recognizes with priority the information that agrees with his/her own idea or interprets the information so as to conform to his/her own idea, thereby causing inappropriate action. We aimed for the developed programs to provide personnel with an understanding of the mechanism by which errors occur and inducing factors of errors and encourage them to formulate countermeasures for themselves.

1 Game

Learners are asked to choose the correct reading of the presented kanji character from four options. One of the options is “not applicable”.

2 Device inducing the intended error

The number of strokes of the kanji character increases one or two strokes each turn (Fig.1). While answering the questions, the learner comes to presume that the next question will certainly be on a kanji with more strokes. When they see a symbol like a kanji in the last question, they will tend to choose the option for the reading of the predicted kanji.

3.2 Error Due to Careless Decision

An error due to careless decision is one due to failure in attention control, called an “action slip”, where a person makes an error in dealing with a rare event on the mistaken assumption that it should be the same as usual. It has been proven that the
greater the time pressure is, and the smaller the visual difference between the stimulus to react to and the stimulus to prevent reaction to is, the more commonly errors due to careless decision occur.11)

(1) Game
According to predetermined conditions for a face (ex. a face with a nose like that of a pig is a face of an alien), learners judge whether the person shown on the screen one by one is a human or an alien (Fig. 2).
(2) Device inducing the intended error
Humans are frequently shown while aliens are seldom shown. As the learner continues answering “a human”, he or she can carelessly judge an alien rarely shown as being a human.

3.4 Error Due to Violation of Rules
An error due to violation of a rule is intentional deviation from a rule by a person.12) Such intentional action is rooted in incorrect recognition or decision, such as “no problem should occur even if not following the rule.” The person did not intend to make such an error, so the violation can be seen as human error in this context. Compared to an error in which the person does not intend to deviate from the rule at all (ex. an error due to assumption), violation of rules can be induced by more complex factors.12) We focused on two of those complex factors, namely “job being habitual” and “workload” in this research.

3.4.1 Violation of Rules Fostered by the Job Being Habitual
(1) Game
Learners are asked to fly five balloons after inflating them with the appropriate amount of air. The rule to follow is to check the amount of air in the balloon visually and by using a tool to measure the amount of air (Fig. 4).
(2) Device inducing the intended error
Humans are frequently shown while aliens are seldom shown. As the learner continues answering “a human”, he or she can carelessly judge an alien rarely shown as being a human.

3.3 Communication Error
A communication error is an error where information cannot be correctly transmitted due to a difference in the image of a word between the transmitter and the receiver.13)
(1) Game
Learners are asked to choose one of the four option pictures that best fits the keyword (Fig. 3). Each question has no correct answer.
(2) Device inducing the intended error
The rates of the options being chosen are shown in a pie chart. Based on data of responses of general participants in a preliminary survey, the options selected for the game are those with large variation in response. By showing the possibility that different persons can receive different meanings from a single expression, the learners can realize how easy discrepancy in communication occurs.

Fig. 1 Program on Errors Due to Assumption
Fig. 2 Program on Errors Due to Careless Decision
Fig. 3 Program on Communication Errors
Fig. 4 Program on Violation of Rules Fostered by the Job Being Habitual
Fig. 5 Program on Violation of Rules Fostered by Heavy Workload
air measuring tool, and they gradually come to check the amount of air only visually. The fifth round is set to result in a failure if the learners violate the rule.

3.4.2 Violation of Rules Fostered by Heavy Workload
(1) Game
Learners are asked to click numbers in order from 1 to 20 from the numbers shown on the screen. While confirming that the number clicked flashes in a different color, they are to answer whether or not any of the numbers is omitted (Fig. 5).
(2) Device inducing the intended error
The game requires learners to click each number and check that it flashes in a different color. Such a procedure using both the hands and eyes applies a larger workload on the learners than looking at numbers alone does. The answer required is on omission of any of the numbers, so the learners easily feel clicking bothersome, inducing them to omit clicking. Since the problems in the first half have no numbers omitted, the learners tend to omit checking by clicking the number toward the second half. In the feedback, the results are shown as not only the correctness regarding omission of the numbers, also showing conformity to the rule of clicking the number.

4 Field Office Trials
After the preliminary survey with general participants, we tested the games and commentary with employees at field offices to gain their assessment. The major objectives were as follows.
(1) To observe the probability of occurrence and patterns of errors the employees make in the game parts, and to verify the appropriateness and reliability of the tasks of individual programs.
(2) To evaluate the ease of understanding and convincingness of the commentary parts that were not evaluated in the preliminary survey.

The participants were 129 employees at field offices in their 20s to 50s. In the test, individual participants played the programs one by one on PCs at their desks.

4.1 Results and Consideration
4.1.1 Error Due to Assumption
The rate of the participants experiencing this type of error was 84%. In the questionnaire after the test, 90% of the participants replied that their level of understanding of the error improved, and 92% said the commentary was convincing.

As the probability of learners experiencing the error was proved to be very high, we could conclude the game part is fairly complete. The commentary part was also confirmed to be very convincing to the employees who are the learners.

4.1.2 Error Due to Careless Decision
The rate of the participants who experienced this type of error at least once was 11%. As shown, the rate is low, but the details of the error where the participants incorrectly answered “a human” for an alien showed a reaction time shorter than with the correct answer of “an alien”. The reason could be that the participants made that error because they were not able to prevent clicking on “a human”. In other words, the participants failed to control their cognitive attention. This confirmed that the error observed was an error due to careless decision.

In the questionnaire after the test, 92% of the participants replied that their level of understanding of the error improved, and 97% said the commentary was convincing.

As the errors that occurred are inferred to be errors to be learned from the lesson, we may need to improve the game part to increase the rate at which similar errors occur.

4.1.3 Communication Error
Variation in the answer was observed with four of the five questions, and almost no variation was found with one question (“What is a typical station?”). In the questionnaire after the test, 95% of the participants replied that their level of understanding of the error improved, and 97% said the commentary was convincing.

The questions of this program were not designed to make the participants directly experience human error. Even so, the level of understanding and convincingness of the participants regarding communication error was high. By replacing the question having small variation in the answer with a different one, the degree of completion could be further raised.

One of the reasons why the participants highly appreciated this program was that the program provided them with fun of finding out what kind of person they are by comparing their choices with those of others. Those “types” have no correct or preferable answer, so the participants are not evaluated on their vulnerability to human errors based on their choices. That is a difference from other learning programs. There is therefore a possibility that the participants appreciated the program as learning materials with which they can learn about errors without anxiety.

4.1.4 Violation of Rules Fostered by the Job Being Habitual
The rate of the participants who experienced this type of error was 34%. However, we were able to observe a tendency where the participants who violated the rule with the last (fifth) balloon by not using the air measuring tool tended to gradually check using the tool less after the first balloon. In other words, as was intended for the device inducing the intended error, we could confirm that their dependency on visual checking rose as the game progressed.

In the questionnaire after the test, 87% of the participants replied that their level of understanding of the error improved,
and 96% said the commentary was convincing.

As with the program for experiencing error due to careless decision, we were able to confirm that the participants experienced the intended error. But, we need to raise the rate of occurrence of that error to make more learners experience the intended error by means such as slightly increasing time pressure.

4.1.5 Violation of Rules Fostered by Heavy Workload
The rate of the participants who experienced this type of error was 25%. In the questionnaire after the test, 86% of the participants replied that their level of understanding of the error improved, and 89% said the commentary was convincing.

As with the program for experiencing violation of rules fostered by the job being habitual, the rate of the participants who experienced violation in this game was as low as 25%, requiring further improvement to increase the number of participants experiencing that violation. However, we also gained a result that the rate of violation was high in the trial with the general participants, so that low rate can be considered be due to the trial environment and the characteristics of employees. For example, in the trial with the general participants, 48 participants in a group tried the program in one room, while just a few participants tried the program in a small room in the trial with JR East employees. Thus, employee participants were possibly more conscious of the experimenter being in the same room than the general participants were. Furthermore, some of employee participants commented that the program was similar to the attention allocation problems in driving aptitude tests. These problems require participants to find the numbers on the screen and to click the numbers found. The employee participants who had experienced the attention allocation problems might have felt the learning program less demanding than the general participants did. This is a possible reason that the rate of violation decreased.

Based on those considerations, we have to brush up the program as a whole and the game part in particular.

5 Conclusion
We are planning to introduce to JR East’s intranet portal site the programs developed in this research. As the portal site has a function where the employees can post information such as their own close-call experiences and countermeasures to those, we can examine those to apply them to the commentary parts. In this way, by involving employees at field office into their own education, we can expect them to be motivated to develop countermeasures to human errors. The programs are themselves also expected to become more practical for those field offices.

Finally, we would like to consider individual differences in the ability and intention to appropriately apply the knowledge learned in the programs to one’s job and situation. To reduce such individual differences, we have introduced examples of accidents by job category group and actual countermeasures in the commentary part. In the future, we will improve and enrich the follow-up system. One possible example of a system is a guide with which the employees at field offices can discuss in their group work how to apply what they learned to countermeasures.

Reference:
6) "Hito wa Donna Mis o Shite Kotsujiko o Okosunoka [in Japanese]", ITARDA INFORMATION, 33, Institute for Traffic Accident Research and Data Analysis (2001)