Experience-based PC Learning System for Human Error Prevention by Point-and-Call Checks

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An experience-based software was developed to help prevent human errors using point and call checks. The five functions comprising point and call checks help prevent human error. Learners were able to experience each error prevention function by going through tasks in the developed software, which corresponded to the five abovementioned functions. The effectiveness of this software in the training for conductors and train operators was also validated. The respective mean subjective ratings for the five functions in point and call checks before and after training were compared. The result indicated that the learners were more convinced of the method’s effectiveness after the training than before it. Some railway companies use this software in their safety education and training programs.

Keywords: point and call check, human error, safety training, accident prevention

1. Introduction

A point and call check is defined as “a method for confirmation of an action by pointing at the object with the index finger and calling out the state of that object or task”. Various workers use it in the various settings in the Japanese railways, including signal validation by train operators, confirming the safety of the platform by the station staff, and inspection of construction work after completion.

Point and call checks are a useful means for preventing human error. Managers in railway companies, however, frequently complain that train drivers make poor use of these checks or none at all, even though they are either recommended or required as a rule. There are a number of possible reasons to explain why train operators don’t perform point and call checks in accordance to recommendations or rules, these include embarrassment or fatigue. A more plausible reason is that it may be difficult for operational staff to recognize the benefit of point and call checks in the course of their work even though experiments show that with these checks error rates generally tend to be lower. In the experiment by Haga et al. (1996), for example, the mean error rate without pointing and calling was 2.38%, whereas with the checks the means fell to 0.38%. Despite this large statistical deviation in error rates participants barely recognized the 2% difference [1].

Consequently the authors developed an experience-based PC learning system designed to make users experience the impact of point and call checks. Using this approach, workers are able to gain a better grasp of the human error prevention effect of point and call checks which can motivate them to use this checking method properly.

2. Human Error Prevention Effect of the Point and Call Checks

Train drivers in Japan consciously use point and call checks in order to prevent themselves from making a human error. For example, train drivers in Japan check a railway signal while pointing at it with their finger and calling out its state.

The human error prevention effect of point and call checks has been validated using choice reaction task experiments [2, 3]. These experiments produced lower mean error rates during task execution with pointing and calling than without. Possible reasons for these findings include the following: (1) pointing helps to fix the gaze on the object for longer, (2) calling reinforces memory of action, (3) calling makes the individual more aware of human error, (4) muscle action in pointing and calling enhances the arousal level [3], and (5) the delay associated with pointing suppresses automatic behavior [1]. Each of the five human error prevention functions in pointing and calling have been assessed [4-6]. This method can be useful in preventing human error not only of train drivers but also any other operator having to observe objects or engaged in complicated processes. There are in fact other types of workers in Japan such as power plant or factories operators or nurses, who also use point and call checks.

3. Experience-Based PC Learning System

This system provides workers with the chance to experience the effect that point and call checks have on preventing human error. The program includes five tasks which correspond to each of the five human error prevention functions making up pointing and call checks: (1) a ‘dot-counting’ task to verify optical acuity by pointing; (2) an n-Back task to verify the effect of calling on memory; (3) a go/no-go task to verify the effect of calling on error monitoring; (4) a ‘clock’ task to demonstrate how alertness is maintained through the act of pointing and calling; and (5) a ‘wait-paper-rock-scissors’ task to verify the impact of delayed action associated with the act of pointing. For each task, workers first perform the trials without pointing or calling; the same tasks are then repeated with either pointing or calling alone or with both pointing and calling. Once the test is over, the learners can visualize the effectiveness
of point and call checks by looking at the graphs showing their error rates.

In the dot counting task, the instructor asks the workers to count dots randomly scattered on the screen. The actual trials are preceded by two practice trials. The actual trials consisted of two sets of five trials. The number of dots differed between trials ranging from 26 to 34 (30 on average). The time allocated for each trial was set according to the number of dots, or 400 ms/dot. In the second set of trials, participants were asked to count the dots while pointing at them.

In the n-Back task, the instructor asked workers to click as quickly as possible on a colored circle from the options displayed on the lower part of the screen, to match a target circle appearing in the center of the screen. The five colored circle options were red, blue, yellow, black, and white. After a first round of reaction trials, the instructor then asked the workers which color they had chosen n selections before (n = 1, 2), by clicking on those options. Each set of trials includes a test to judge recognition. The number of choice reaction trials varied between 12 and 16. In the first session, workers were asked to select a colored circle without saying anything, while in the second session, they were asked to do same while saying the color out loud, followed by a final series where they are asked to perform the test while repeating "the the the the....." out loud. This last procedure is called articulatory suppression. The process is aimed at silencing participants’ inner-voice, to avoid participants being able to mentally pronounce the name of the color. If a participant mentally voices the color in the first series of trials, then the result will be the same as the second series. In such cases, the instructor can demonstrate the effectiveness of calling on preventing human error by comparing the scores obtained in the third set of tests.

In the go/no-go task, the instructor asked participants to press a key as quickly as possible when a distractor stimulus (go stimulus) appeared in the center of the screen, while they were asked to remain still when a target stimulus (no-go stimulus) appeared. The no-go stimulus is a simple line drawing, like Smiley Face, while the go stimulus although similar in drawing style is tight-lipped mouth with the corners turned down. Given that the screen displayed many go stimuli, workers tended to press the key by mistake even when a no-go stimulus appeared. One no-go stimulus appeared on the screen for every 12 to 18 go stimuli (or after 15 on average). Both sets of tests included seven no-go trials each. In the second session, participants were asked to press a key with each go stimuli while saying "Osu" (meaning “push” in Japanese), while remaining immobile for no-go stimuli while saying "Osanai" (meaning “don’t push” or “stay still” in Japanese).

The ‘clock’ task involved four laps in each of the two sets of tests. The instructor asked participants to monitor a sweeping hand and press a key if they detected an irregular two-step in its movement, which appeared once on Lap 2 and 4. The sweeping hand needs two seconds to move one step. In the second session, workers are asked to monitor the sweeping hand while pointing at and saying “Yoshi” (meaning “checked” in Japanese). Workers were then asked to answer two questionnaires after each set of tests. One was about fatigue and the other about anxiety about the possibility of failing to spot the irregular jump. The workers answered both questions by moving a sliding switch on a continuum scale on the screen.

In the ‘wait-paper-rock-scissors’ task, the instructor asked workers to choose a losing option on hearing the last word of the command “Jan, Ken Pon, Pon” among the three alternatives shown at the bottom of the screen according to what appeared in the center of the screen. Each of the two sets of tests consisted of nine trials. In the second set, participants were asked to select their response after first pointing to the hand in the center of the screen and then to their option at the bottom of the screen. In this set of trials, workers were not required to respond on hearing the command word.

4. Experiment

4.1 Purpose

In order to test the effect of training using SIM-ERROR, the authors conducted a series of experiments at a railway company. The SIM-ERROR was developed to raise awareness through training about the benefits of point and call checks in reducing human error. As part of the development, the program was also tested in a practical situation by testing railway operators and asking supervisors to act as trainers.

4.2 Method

A total of 736 apprentice train operators participated in the training. 118 participants performed the dot counting task, 123 participants the n-Back task, 182 the go/no-go task, 155 the clock task, and 158 participants performed the ‘wait-paper-rock-scissors’ task. One of five supervisors dispensed the training.

The experiment was carried out in a group setting. One session included about 35 participants. Each of them was seated in front of a PC. Before each task, participants answered questions on a five-point Likert-type scale (1. Not at all acceptable – 5. Very acceptable) regarding the five human error prevention effects of point and call checks as follows: (1) pointing helps to fix the gaze on the object for longer, (2) calling reinforces memory of action, (3) calling makes the individual more aware of human error, (4) muscle action in pointing and calling enhances the level of alertness, and (5) the delay associated with pointing suppresses automatic behavior. The questionnaire was printed on A4-sized paper.

Participants performed one of the five tasks in the SIM-ERROR following the instructor’s directions and were shown their error rates for each set of tests in the form of a bar graph after the task. Tasks were allocated in random order from group to group. The instructor explained each task, the general trend of the results, the human error prevention effects of point and call checks in relation to each task, the link between experience gained from performing the tasks and work in the field, and other human error prevention effects of pointing and calling. At the end of the session, participants were asked to once again complete the questionnaire filled out commencing the tests. Each
session, including the tasks, the questionnaires, and explanations from the instructor, took about 30 minutes on average.

4.3 Result

The mean subjective rating for each of the five point and call check functions before and after the training sessions were compared (Fig. 1).

The 2 x 5 mixed configuration ANOVA (ANalysis Of VAriance) showed the main effect of the training \((F(1, 731) = 15.88, MSE = 0.27, p < .01, \eta^2 = 0.02)\), the task \((F(1, 731) = 6.49, MSe = 0.68, p < .01, \eta^2 = 0.02)\), and the interaction effect \((F(4, 731) = 23.38, MSe = 0.27, p < .01, \eta^2 = 0.03)\). These results mean that the training improved participants’ subjective perception of point and call checks overall but actual effect depended on the tasks.

In order to bring out interaction effect, a simple main effect test was conducted for each task. The result indicated that the mean subjective ratings after training increased in the ‘wait-paper-rock-scissors’ task \((F(1, 731) = 118.90, MSe = 0.27, p < .01, \eta^2 = 0.16)\), the go/no-go task \((F(1, 731) = 15.73, MSe = 0.27, p < .01, \eta^2 = 0.02)\), and the ‘clock’ task \((F(1, 731) = 18.84, MSe = 0.27, p < .01, \eta^2 = 0.03)\). However, no differences were found in the dot counting task \((F(1, 731) = 3.27, MSe = 0.27, p > .05, \eta^2 = 0.004)\) or the n-Back task \((F(1, 731) = 0.16, MSe = 0.27, p > .05, \eta^2 = 0.0002)\). These results indicate that, at least, the training on impulse suppression with pointing and the ‘wait-paper-rock-scissors’ task, on human error detection with calling and maintaining level of alertness by pointing and calling was effective in raising awareness about the benefits of point and call checks.

In order to answer the question on why the other training tasks did not affect awareness in the same way, a simple main effect test was conducted to gain more insight into the differences from before and after training. The result showed that some difference existed between tasks before training \((F(4, 731) = 19.09, MSc = 0.55, p < .01, \eta^2 = 0.10)\) while there was no difference after training \((F(4, 731) = 0.43, MSc = 0.55, p > .05, \eta^2 = 0.002)\). Paired comparisons of tests in each task before training showed that both eye-focusing with pointing and memory improvement with calling had the highest and similar subjective ratings \((MSc = 0.55, p < .05, LSD = 0.17)\). This result indicates that participants already had high awareness about both these effects before training. As such, absence of further differences in subjective ratings before and after training might indicate a ceiling effect.

4.4 Discussion

In summary, the results indicated that the participants were more convinced of the human error prevention effectiveness of point and call checks after training than before it. Of course, there were no increments in two tasks; dot counting for optical acuity by pointing and the n-Back task for memory with calling, however for these two cases, it was shown that participants were already sufficiently aware of their effect even before the training.

Participants’ enhanced awareness after the training experience can probably be explained on grounds of empa-
thy. Prior research indicates that empathy requires similar experience [7-9]. It is difficult for workers to experience the effect of pointing and calling on human error prevention at work because human error is rare. The system therefore provided participants with the chance to experience human error and the prevention effect of pointing and calling. This therefore enhances the aforementioned awareness. Although not described in this paper, mean error rates in the case of pointing and/or calling alone were lower than those without pointing and/or calling at all for all tasks. These results indicate that through the training participants were able to see the human error prevention effect.

5. Conclusion

An experience-based PC learning system was developed to raise awareness about the effectiveness of point and call checks in preventing human error and its efficacy it was confirmed experimentally. Some major railway companies and industrial plants use the system for safety training. Each session for performing one of the series of tests associated with each task in the system required between thirty or forty minutes, including instruction, execution and feedback on the task. The current version of the system requires each participant to have access to a PC. A simplified version is being developed which needs only one PC for the instructor, a projector and a screen. This modification may facilitate the introduction of the system to smaller companies.

References