The Error Prevention Mechanisms of Pointing: Eye Focusing and/or Memory Enhancing?

Takayuki Masuda[1], Masayoshi Shigemori[2], Yasuhiro Kitamura[1], and Naohiro Akiu[1]

[1] Human Science Division, Railway Technical Research Institute,
2-8-38 Hikari-cho, Kokubunji-shi Tokyo, 185-8540, Japan
[2] Department of Contemporary Communication, Shizuoka Eiwa Gakuin University Junior College, 1769 Ikeda, Suruga-ku, Shizuoka-shi, Shizuoka-ken, 422-8545, Japan
{Masuda,kitamura,akiu}@rtri.or.jp, gemo@h9.dion.ne.jp

Abstract. The error prevention effects of "point and call checks (P&C Checks)" are known and used in several industries in Japan. We investigated whether or not "pointing" had an error prevention effect and if the effect is due to eye focusing. Participants performed tasks under different experimental conditions: (1) with pointing, (2) without pointing. The density of the dots were controlled (high or low). This task had two subtasks. One, focusing on the only target dots and two, remembering the dots which have been counted. The result indicated that only in low density condition the number of counting error in "with pointing" conditions was significantly fewer than that in "without pointing" condition. The result supported the memory enhancing effect of pointing.

Keywords: "point and call checks", human error, error prevention.

1 Introduction

In various industries, human error is indicated as the main cause of accident. For the purpose of preventing human error, several tangible and intangible countermeasures have been developed. Although both countermeasures are important for enhanced safety, tangible countermeasures usually get most attention. Intangible measures are also important for safety. "Point and call checks (P&C Checks)" is one form of intangible countermeasure broadly used in various industrial fields in Japan. Various workers, for example train drivers, factory workers, plant workers and nurses use P&C Checks in complicated perceptual situations or when operating complicated systems in order to prevent errors. In the railway field, various workers, not to mention train drivers and conductors, use P&C Checks in Japan. For example, train operators check a railway signal while pointing at it with their finger and calling out its state. Maintenance workers check project status with P&C Checks, too. P&C Checks is a method for confirming an action or status by pointing at the object or task with index finger and calling out its state or status [1]. Several studies have demonstrated that the P&C Checks have error prevention effects, but the error prevention mechanisms of P&C Checks have not been verified sufficiently. Therefore we need to confirm each mechanism in detail.

C. Stephanidis (Ed.): Posters, Part I, HCII 2013, CCIS 373, pp. 432–436, 2013.

In this paper we focus on the mechanism of eye fixation with pointing. We experimentally investigated whether or not "pointing" had an error prevention effect and if the effect is due to eye focusing. We compare the error rate in the task of counting dots on the PC display in high and low density conditions. This task had two subtasks. One, focusing on only target dots and two, remembering the dots which have been counted. For the purpose of confirming the eye focusing effect of pointing, eye movements were recorded. Because of the deterioration of the data due to the head movement of the participants, the data was not analyzed. Details of the results of the eye tracker data will therefore not be fully described.

2 Procedure

2.1 Participants

Forty people (nineteen male, twenty one female) participated in the study; they had the mean age of 21.35 years. All participants were aware of their right to withdraw from the study at any time and had a full debriefing about the aims of the study.

2.2 Equipment

We collected data using the experiment software (developed with Microsoft Visual Basic 2010). Experiment software was installed to the PC (FUJITSU FMVDE2A0L1). Output was shown on the 17in. display (Mitsubishi RDT1713LM) at 1024 × 768 pix. The responses of participants were recorded with a keyboard connected to the PC. The display was positioned 60 cm from the participants.

2.3 Task

The task was to count the dots on the display. This experiment consisted of two sessions. The first session was a trial session. Participants performed the task under different experimental conditions: (1) with pointing, (2) without pointing. The density of the dots was controlled (high or low: Figure 1). In the trial session, participants experienced one high density trial and one low density trial without pointing, and the order was randomly selected. One session consisted of twelve trials: six high density trials and six low density trials in each experimental condition. Each trial was selected randomly. With or without tests alternated. The dot density was controlled not to be the same in the six consecutive trials. In the trial session, forty dots on the screen in one trial. In one session, the number of the dots on the screen was selected from 37, 38, 39, 41, 42, 43 (average 40).

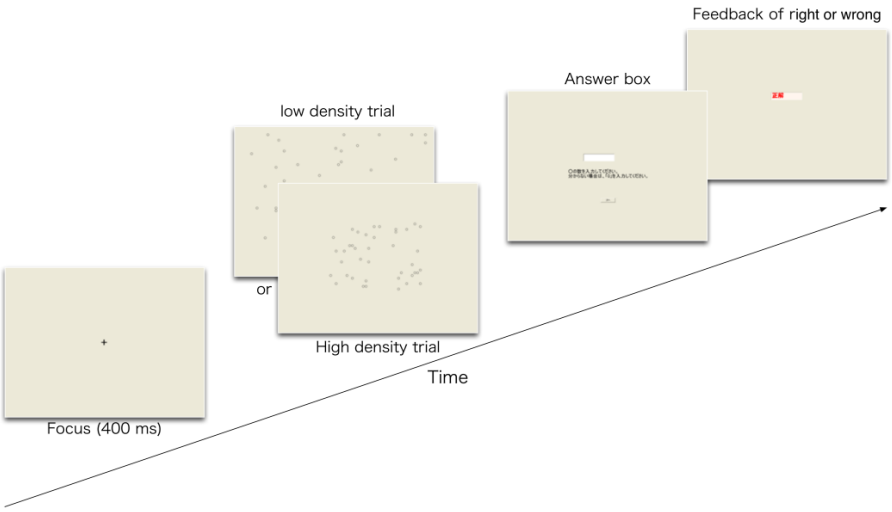

Fig. 1. Flow of experiment

The screen was divided into the 70 x 50 arrays of cells. In high density trials, the locations of the dots presented on the screen were selected from all cells. On the other hand, in low density trials, the locations of the dots presented on the screen were selected from limited cells (from rows eighteen to fifty three and from columns thirteen to thirty eight).

The dots were presented for 400ms per each dot. When forty dots were presented, dots were presented for 16000ms.

3 Hypothesis

If the error prevention effect of pointing is due to the effect of eye focusing, the error prevention effect should be revealed more clearly in high density condition than in low density condition, because focusing on only target dots is more difficult. On the contrary, if the error prevention effect was revealed more clearly in low density conditions than in high density conditions, then pointing may have memory enhancing effect. The result indicated that only in low density condition the number of counting error in "with pointing" conditions was significantly fewer than that in "without pointing" condition. The result supported the memory enhancing effect of pointing.

4 Results

4.1 Control of the Density of Dots

In order to confirm the control of the density of dots, analysis of variance was conducted. The results indicated that the main effect of the density and the average

distance between dots in high density condition was fewer than that in low density condition ($F(1, 39) = 23358.28$, $p < .01$). There was no main effect of with/without pointing and interaction between with/without pointing and density of dots. These result validated the control of the density of dots.

4.2 Error Rate

Analysis of variance (ANOVA) was conducted to examine the effects of with/without pointing and density of dots. The results indicated that the main effect of with/without pointing and the number of wrong count in with pointing condition was significantly fewer than that in without pointing condition ($F(1, 39) = 4.20$, $p < .05$). There was no significant interaction between with/without pointing and density of dots ($F(1, 39) = 1.20$, n.s.).

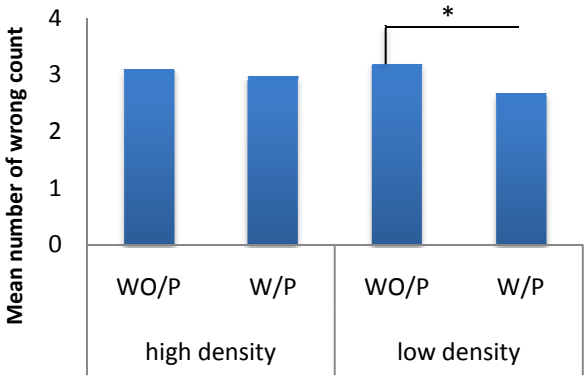

Fig. 2. Error rate in each experimental condition (*: $p<.05$)

Although, significant interaction between with/without pointing and density of dots was not seen, a t-test was conducted to examine the effects of with/without pointing in each density conditions. The result indicated that the number of wrong count with pointing condition was significantly fewer than that without pointing condition in low density condition ($t = 2.07$, $df = 39$, $p<.05$). There was no difference between with pointing condition and without pointing condition in high density condition ($t = 0.54$, $df = 39$, n.s.).

5 Discussion

Although, significant interaction between with/without pointing and density of dots was not seen, the result of t-test indicated that error prevention effect of pointing was seen only in low density condition.

One interpretation of this result is that error prevention effect of pointing is not only due to the effect of eye focusing, but may be due to other error prevention

mechanism. One possibility is that pointing has the memory promoting effect. Pointing accompanying physical movement may prompt spatial memory. Consequently, error prevention effect of pointing was seen only in low density condition. In order to count the dots accurately, remembering what dots have already been counted is important. Therefore, it can hardly be assumed that eye fixation have no relation with error prevention effect. Because of the deterioration in the accuracy of the eye tracker calibration, we couldn't test the difference in eye fixation between each experimental condition. As a result, we can't test to what extent eye fixation has relation with prompting memory and error prevention. We need to perform further experiments under various density conditions and to research using eye camera.

Identifying the error prevention mechanisms is important not only in terms of academic progress, but also in terms of application to the field. One application is to education. Intangible counter-measures such as P&C Checks are easy to lose popularity. Learning the mechanisms of P&C Checks may contribute to enhanced understanding and retention of P&C Checks. We need further experiments to identify the error prevention mechanisms and to examine them in detail.

Reference

1. Shigemori, M., Sato, A., Masuda, T., Haga, S.: Human error prevention effect of point and call check used by railway workers in Japan. In: Dadashi, N., Scott, A., Wilson, J.R., Mills, A. (eds.) Rail human factors supporting reliability, safety and cost reduction, pp. 599–608. CRC Press (2013)