

Eye Movement in the Development of an Everyday Skill

Harumi Kobayashi (h-koba@i.dendai.ac.jp) and Tetsuya Yasuda

Graduate School, Social Informatics, Tokyo Denki University,

Hatoyama-cho, Hiki-gun, Saitama 350-0394, Japan

Abstract

This study examined whether eye movement changed as a person developed an everyday skill. The participants were asked to make instant coffee ten times consecutively using their non-dominant left hand. Their eye movements were recorded by an eye tracker. The video data were coded by a frame-by-frame method. The results showed that the duration of fixation to the materials decreased as the participant repeated the task, whereas the duration of fixation to the target cup at hand was constant. The results suggested that the duration of fixation to relevant objects decreased as a human established visual memory of object positions.

Keywords: eye movement; everyday task; duration of fixation.

Introduction

Eye movement may reflect a person's internal states, which are typically difficult to observe. Hayhoe (2004) suggested that the position of the fixation point, time duration, timing, and accuracy can be important measures that reflect person's internal states. Eye movement has been studied in various visuo-motor tasks, such as driving, sports, and other everyday activities like making tea or sandwiches (Land, 2004; Hayhoe, et al., 2003). Previous literature showed that eye movement is closely linked to the task structures if there are distinctive procedures in these structures. The studies also showed that the eyes are positioned at only task-relevant objects. Irrelevant areas are rarely fixated. In addition, eyes are fixated on not necessarily the most visually salient object, but the best object or area for the spatio-temporal demands of the job that needs to be done (Land & Hayhoe, 2001). In our preliminary studies of eye movement in the everyday activity of coffee-making (Kobayashi & Yasuda, 2005), we showed that participants fixated task-related objects more often than task-unrelated objects confirming some results of previous studies. However, our study did not consider the possibility that the difficulty may vary among task-related activities. People may not have to fixate on objects in easy task that does not require much learning, whereas they may fixate on objects more frequently and for a longer time in difficult task that require substantial learning.

In the present study, we examined whether a participant looked at related but an easy object less than they looked at related and difficult objects in the course of skill development. The easy object was a cup at hand. The

difficult objects were cups of various positions. The participants were asked to make instant coffee using their non-dominant left hand. We expected that we could better understand a person's skill development if we analyzed the motions of a yet unskilled hand. The eye movements were recorded by an eye tracker. The video data were coded by a frame-by-frame method in terms of the target of fixation.

Method

Participants

Participants consisted of eight male university students who could make instant coffee without eyeglasses or contact lenses. All were right-handed and the age range was from 20 to 23 years.

Apparatus

There were a chair and a table that were surrounded by screen boards so that the participant could easily concentrate. Another small table was also set near to the participant's table so that cups for materials for the next trial could be prepared. Three video cameras recorded the experimental situation, but only the video data of the center camera (DigiMo, an attachment of Sensor Cube 8, sampling rate 29.97 frames/sec) were taken for analysis. Images of the other cameras were used to confirm the process of the experiment by the experimenters. The participant put a cap on his head on which an eye tracker (Eye mark-recorder, NAC Image Technology, EMR-8B, sampling rate 30Hz) was mounted. This system uses an infrared video camera to capture pupil and the corneal reflection. The camera mounted on the cap recorded the scene from the observer's viewpoint. The position of the eye gaze was superimposed on the video record of the scene. Figure 1 shows the positions of the experimental materials.

Procedure

The participants were asked to make coffee using their non-dominant left hand. The right hand could be used to hold the paper cup when such an action was necessary. The participant could use more than one spoon and stirrer in making one cup of coffee, but each spoon and stirrer could be used only once in each trial. Two participants' data were dropped because of measuring errors, so the remaining six participants' data were analyzed. We defined that the fixation was observed when an eye mark (gaze point in EMR-8) was retained on something in two or more consecutive frames (i.e., 0.06 sec) This relatively short

duration was selected because we did not overlook unsystematic brief look at materials that may help establishing visual memory of material positions. Then we categorized the targets of fixation into pre-determined categories, including task-relevant objects such as coffee powder, sugar, and the target cup, and irrelevant objects such as rice, a part of the experimental table, etc. Based on the coded data, we calculated the frequency and time when the eye gaze was directed to an object in each trial.

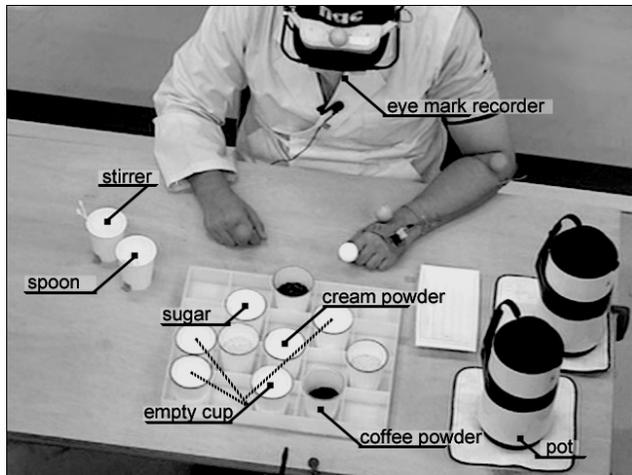


Figure 1: Positions of the experimental materials

Results and Discussion

We calculated the total time for making each cup of coffee. The starting point was when the experimenter said, "Start," and the end point was when the participant indicated he finished making one cup of coffee. A two-sample t-test with repeated measures was executed between the time spent for the first three trials (1st, 2nd, and 3rd cups, $M=63.5$ sec) and the last three trials (8th, 9th, and 10th cups, $M=56.4$ sec). There was a significant difference between these two samples, $t(6)=2.498$, $p=0.0467$. This shows that the mean time spent decreased as the participants repeated the task.

Based on the coded data, we calculated the duration of fixation on related materials and the target cup at hand (Figure 2). The materials included coffee powder, cream powder, and sugar. The target means the cup at hand in which the ingredients are mixed to make a cup of instant coffee. In the related materials data, there was a significant negative correlation between the number of trials and duration of fixation, $r=-0.928$, $p<0.0001$ whereas there was no correlation in the target cup data.

These results indicate that as the participant repeated the task of coffee-making, the required time decreased, suggesting that the participants certainly developed coffee-making skills. The duration of fixation on the materials decreased as the participant repeated the coffee-making, whereas the duration of fixation on the target cup was constant in the ten trials. Thus, among

task-related fixations, fixation on an object whose position was easy did not decrease whereas fixation on the other related objects did decrease. We interpreted that a person tends to look at a related object less as he develops a skill, but if the position of the related object is easy, the duration of fixation remains at a low level. It may be suggested that establishing visual memory of object positions results in quicker and more efficient eye movement.

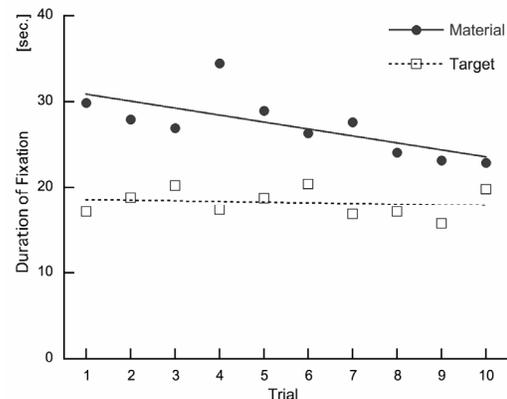


Figure 2: Duration of fixation on materials and the target.

Note. The materials were coffee powder, cream powder, and sugar. The target was a target cup in which the ingredients were mixed and instant coffee was made.

Conclusion

We investigated eye movement when a person repeated a coffee-making task. The results suggested that the duration of fixation on objects decreased as a person established visual memory of the object positions.

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