Eye-hand Coordination in Development of a Natural task: Making ten cups of coffee

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Introduction

Eye movement has been typically studied on non-natural tasks, so we have limited understanding of how visual processes operate in the service of natural daily tasks. This study investigated the temporal relationship of natural vision and hand reaching by measuring eye and hand movements while participants made ten cups of coffee. It has been shown that much natural vision is accomplished with "just-in-time" representation of target objects (Land, Mennie, & Rusted, 1999; Hayhoe, Shrivastava, Mruczek, & Pelz, 2003), but some "look ahead" fixations are also observed (Hayhoe, et al., 2003). The goal of the present investigation was to examine whether fixation patterns in natural behavior changed when a human repeated and developed a natural task.

Method

Participants

The participants were six male graduate and undergraduate students from 21 to 24 years old. They are all right-handed and did not have history of neurological deficits.

Apparatus

The participant wore a cap on which an eye tracker (NAC Image Technology, EMR-8B, sampling rate 30 Hz) was attached to record his eye movement. Three video cameras shot 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 experimental process.

Procedure

The participant wore the eye tracker mounted on the head and sat in front of a small table on which cups, coffee powder, sugar, cream, spoons, stirrers, pots, tray, bread crumbs, coffee beans, and rice were placed. Bread crumbs, coffee beans and rice were distracters. The materials such as coffee powder and sugar were put in containers. The participant made ten cups of instant coffee with non-dominant left hand. After each trial (i.e., making one cup of coffee), there was a one-minute interval when the participant had rest remaining eyes closed. The material containers were replaced by new and complete ones that included the same weight of each material. We analyzed movement of participant eye movements that was recorded by the eye tracker. We defined that a fixation was observed when a fixation mark was retained for more than 0.197 sec (i.e., 6 frames) on something. Following data collection, the video records were analyzed on a frame-by-frame basis, recording the time of initiation and termination of each eye and hand movement, the location of the fixation, and the type of the hand actions.

Results and Discussion

We measured the latency between eye and hand movements for all the reaches that the participant made. The initiation of both eye and hand movements was taken from the video record, using the first frame on which a translation could be detected. The frequency distributions of eye-hand latencies for six participants are shown in Figure 1. It shows that the total frequency of fixations in the 9th and 10th trials was less than that in the 1st and 2nd trials. Precedent eye gaze before the reaching motion became close to zero in the 9th and 10th trials. The frequency of fixations to see a target object decreased as the participant developed coffee-making skill. The patterns of fixation may be caused by the participant's establishment of visual memory of the object positions. The study suggested that eye-hand coordination changed as a human developed a daily task.

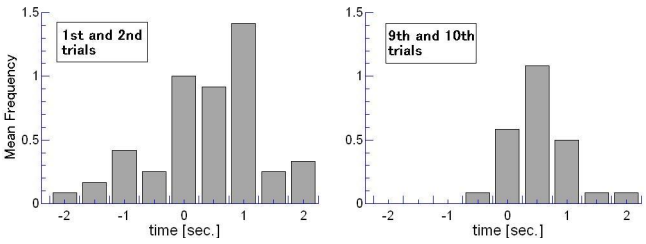

Figure 1: Mean eye-hand latency distribution for 6 participants.

Note. Eye-hand latency was calculated by the time of initiation of each eye movement minus that of each hand movement.

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