Predicting future position of three-dimensional moving objects
—Effect of tracking eye movements—

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We investigated the effects of tracking eye movements on predicting a future position of a three-dimensional moving object. Each stimulus movie was composed of four object frames. The participants judged whether the fourth object frame contained an object which had been changed an equivalent amount to the object in the second and third object frames. The results showed that tracking eye movements are required to accurately predict the future position of a moving object although cast shadows are also necessary for the prediction of the three-dimensional rotation. The results therefore imply the existence of a labeling mechanism which is mediated by tracking eye movements.

Key words: prediction of motion, tracking eye movements, cast shadow

Introduction

This study examined whether or not tracking eye movements affect the performance of predicting the future position of a moving object. It has been suggested that the future position of a moving object is underestimated (Finke & Shyi, 1988). In this study we hypothesized that eye movements would give an additional cue for the prediction because tracking eye movements often co-occur with a change of image frame, and consequently the visual system is likely to associate the eye movements with the representation which is to be accumulated.

Method

Stimuli Figure 1a shows an example of the stimuli used in Experiment 1. A frame containing the object (an object frame) was presented for 250 ms, and this was followed by an interval for 250 ms. Each stimulus movie was composed of four object frames and four intervals.

In each of the second and third object frames the object was rotated by 25 degrees either clockwise or counterclockwise about its axis. In the fourth object frame, the object was rotated by either 19, 21, 23, 25, 27, 29, or 31 degrees. The relative rotation angles were therefore: 6, 4, or 2 degrees, indicating an undershot of the rotation; 0 degrees; 2, 4, or 6 degrees, indicating an overshoot of the rotation. Half of the stimulus movies had a cast shadow but the other half did not.

Figure 1b shows an example of the stimuli used in Experiment 2. The duration and presentation order of the frames were the same as in Experiment 1. The object was a sphere and it moved to the right or left by a visual angle of 1.43 degrees in each of the second and third object frames. In the fourth object frame, the object was presented as moved by either 1.00, 1.144, 1.287, 1.43, 1.564, 1.716, or 1.859 degrees (equivalent to either 21, 24, 27, 30, 33, 36, or 39 pixels). The relative movement distance was either 9, 6, 3, 0, 3, 6, or 9 pixels, respectively.

Procedure The participants indicated with assigned keys their judgment of whether the fourth object frame contained an object which had been rotated an equivalent amount (Experiment 1) or moved an equivalent amount (Experiment 2) to the object in the second and third object frames. In the "fixation condition" the participants were encouraged to look at a fixation point presented at the center of the display. In the "tracking condition", they were required to track a thin arm indicated by the experimenter.
Results and Discussion

The response biases of the participants were computed from the weighted mean for each condition and are shown in Figures 1c and 1d. The error bars are the 95% confidence intervals. The results showed that in the “tracking condition” of Experiment 1 (Figure 1c) the predictions were accurate for the objects with cast shadows. In Experiment 2 the predictions for the objects both with, and without, cast shadows were accurate in the “tracking condition” (Figure 1d).

These results show that tracking eye movements can play a critical role for prediction of the future position of a moving object. In Experiment 2, the predictions that were made with tracking eye movements were accurate. We propose that this is because the tracking eye movements labeled the representation of the moving objects and the stored representation became more accurate.

Moreover, we have shown in Experiment 1 that a cast shadow is also required to predict the future position of a three-dimensional moving object. The motion of the three-dimensional objects in Experiment 1 did not seem to be projected equivalently on the retina, that is, image compression occurred near the edge of objects. Therefore we propose that for an accurate prediction a three-dimensional cue, such as cast shadow, was required to accurately perceive the distance traveled by the moving objects. On the other hand, the sphere used in Experiment 2 did not cause distortion of the projected image. Therefore only tracking eye movements were required for an accurate prediction.

References