THE TIME NEEDED FOR DETECTING CHANGES IN MOTION PATTERN

Tadayuki Tayama
Department of Psychology, Hokkaido University,
N10 W7, Kita-Ku, Sapporo, 060-0810, Japan
<tayama@psych.let.hokudai.ac.jp>

Abstract

Three experiments were carried out to measure the time needed to detect changes in a motion pattern. In Experiments 1 and 2, observers were asked to judge whether a change of test pattern or a change of color at the edge of the test field occurred first, while simple response times were examined in Experiment 3. In each experiment, there were five tasks corresponding to five kinds of changes in test pattern: changes of the abrupt appearance (onset) and disappearance (offset) of motion pattern, those of stationary-to-moving and moving-to-stationary patterns, and those of velocity. In all experiments, detections of change in the onset task were faster than those in the stationary-to-moving task, and in the latter, detection time decreased with the increase of velocity. Moreover, in the velocity-change task, detection was faster in the decelerated condition than in the accelerated condition. The results of the offset and moving-to-stationary tasks were inconsistent among experiments.

People need time to detect physical changes in direction or velocity of moving stimuli. Studies of response time have shown that the larger the difference between directions or velocities when these change, the less time it takes to detect the change (Mateeff et al., 1995, 1999). Moreover, it is known that response times to abrupt appearance or disappearance of motion stimuli decrease with velocity (Hohnsbein & Mateeff, 1992). However, response time is not necessarily a suitable measure to investigate the process of detecting change, because extra time concerning a motor system will be involved. Therefore, in this study, detection times for changes were measured by a different method: temporal order judgments (TOJ), which do not involve a motor system. The results for these will be compared with those for response times. In Experiments 1 and 2, observers were asked to judge temporal order of changes correctly. In Experiment 3, they were asked to respond to changes quickly. This study investigated the abrupt appearance and disappearance of motion patterns, the change from a stationary pattern to a motion pattern and vice versa, and velocity change, as stimulus changes.

Experiment 1

In Experiment 1, detection times to changes were measured using TOJ and a modified up–down method. Apart from the changes of test pattern mentioned above, the edge of the test field was colored and it changed from green to red. The observers were asked to judge whether changes of test pattern or color occurred first.

Methods

Observers. Five undergraduate students participated in the experiment.
Apparatus and stimuli. Test patterns were presented in the center of a 17-inch monitor controlled by a personal computer. These were plaid patterns composed of two sinusoidal

gratings with a spatial frequency of 1.0 c/deg. Each grating was oriented +45 degrees and –45 degrees from vertical. The size of the test field was 2.6 × 2.6 degrees. The peripheral area (more than 1.33 degrees from the center) of this field was blurred by a Gaussian filter so that the observer could not use luminance changes of the edges as reference stimuli for discrimination judgment. When the velocity of the motion pattern changed, the phase in the plaid was succeeded. Test patterns always moved in a vertical direction. The color of the edge changed from green to red. The observation distance was 84.88 cm. The luminance of the background area surrounding the test pattern was 6.0 cd/m^2. The experiment was conducted in a darkroom.

Tasks and experimental conditions. Each observer participated in five tasks: the onset (ON), offset (OFF), stationary-to-moving (STM), moving-to-stationary (MTS), and velocity-change (VC) tasks. In each task, the observer was asked to judge whether changes of test pattern or color occurred first. While motion pattern abruptly appeared in the ON task, it disappeared in the OFF task. In the STM task, the motion pattern changed from a stationary pattern to a motion pattern; the MTS task was the reverse. In the VC task, the motion pattern moved in the same direction but the velocity changed. The test pattern moved upward or downward when it moved and the direction was randomly selected for every trial. There were four kinds of velocity conditions of 0, 2, 8, and 32 deg/s. Moreover, detection times were measured under two conditions of upper and lower discrimination thresholds.

Procedure. In all but the ON task, the test pattern with the green edge was first presented with a beeping sound. The test pattern was shown for 640 ms, after which it was changed and shown for another 640 ms. The color at the edge was changed to red temporally close to the change of test pattern. The observers were asked to judge the temporal order between two changes by pushing one of two keys. If they perceived the change of test pattern first, they pressed the left key, and if they perceived the change of color first, they pressed the right key. This was one trial. Two changes coincided perceptually with the number of trials. In the condition of upper discrimination, the change of color became faster by 10 ms in the next trial if they pressed the left key twice in a row but delayed by 10 ms if they pressed the right key once. In the condition of lower discrimination, the change of color became faster by 10 ms if they pressed the left key once but delayed by 10 ms if they pressed the right key twice in a row. Trials for one measurement were finished when 10 turns from decreasing to increasing trials and vice versa were completed. Six duration values corresponding to the last six turns were averaged and recorded as detection time. The ON and STM tasks were conducted in one session, in which the order of the velocity condition was randomized for each session. This was also done for the OFF and MTS tasks. Each observer conducted one measurement for each condition in each task and completed a total of 40 measurements.

Results

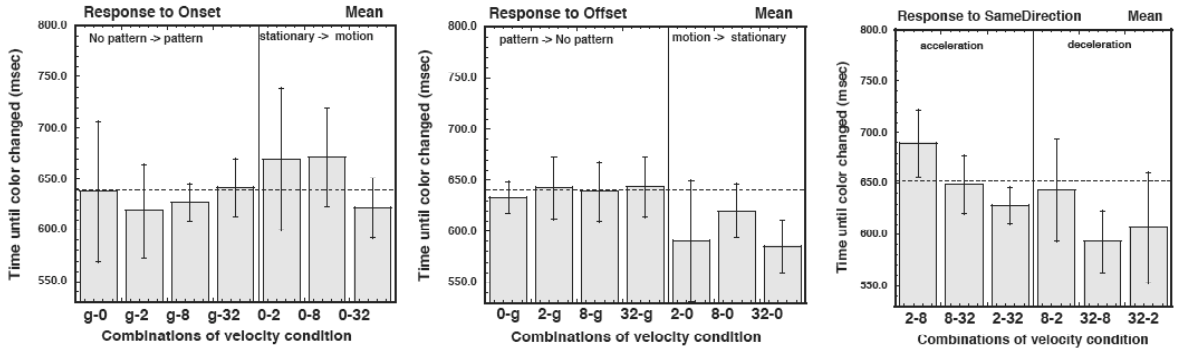

Fig.1. The results of Exp. 1(TOJ by the up-down method). The number in velocity

condition indicates the velocity (deg/s) but g indicates no (gray) pattern.

Mean detection time was calculated for each condition in each task. The results are shown in Figure 1 and summarized as follows. (1) The detection of changes in the ON task was faster than in the STM task. In the STM task, the influence of velocity was observed and the detection time decreased with the increase of velocity. (2) The detection of changes in the MTS task was faster than that in the OFF task. There was no influence of velocity in the OFF task, while the influence of velocity was ambiguous in MTS task. (3) In the VC task, the detection of changes was faster in the decelerated condition than in the accelerated condition. The detection in the former condition was faster with the increase of difference between velocities.

Experiment 2

In Experiment 2, detection time was measured using the same TOJ method as in Experiment 1. However, in this experiment, temporal conditions were established based on the mean detection times obtained in Experiment 1, and the constant method was used instead of the up–down method.

Methods

Five undergraduate students, different from those in Experiment 1, participated in this experiment. Although the methods were almost the same as those used in Experiment 1, the procedure differed slightly. There were seven kinds of temporal conditions: ±80, ±40, ±20, and 0 ms. The color of the edge changed from green to red at the time when the detection time obtained in Experiment 1 plus one of the seven temporal conditions passed. The observer responded by pushing one of two keys in the same way as in Experiment 1. The ON and STM tasks were carried out in one session, for which the order of velocity condition was randomized. The OFF and MTS tasks were as above. Each observer carried out 98 trials in each session of these tasks and 84 trials in each session of the VC task. Each session was repeated five times.

Results

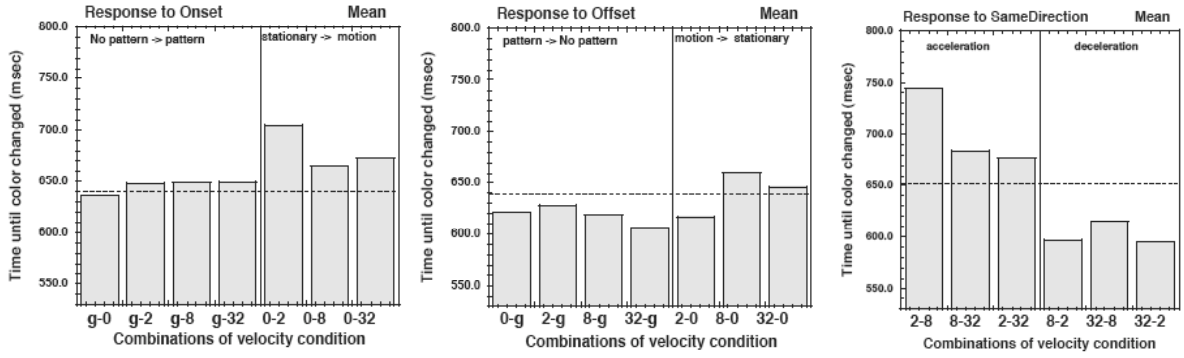

Fig.2. The results of Exp. 2(TOJ by the constant method). The number in velocity condition indicates the velocity (deg/s) but g indicates no (gray) pattern.

The response ratios of test patterns were first plotted as a function of temporal conditions from +80 ms to –80 ms. The data were fitted to a logistic function and the time corresponding to a ratio of 50% was estimated as the detection time for the condition. The values are shown

in Figure 2. The results may be summarized as follows. (1) The results in the ON, STM, and VC tasks were almost the same as those of Experiment 1. However, unlike Experiment 1, the influence of velocity was hardly observed in the ON task. (2) The results in the OFF and MTS tasks were the opposite of those in Experiment 1 and detection in the OFF task was faster than in the MTS task.

Experiment 3

In Experiment 3, simple response times to changes were measured under almost identical conditions, including the same observers, as in Experiment 2. In this experiment, test patterns were presented without the colored edge.

Methods

The tasks were the same as those of Experiments 1 and 2, except that a control task was also included in which only the color of the edge changed from green to red. The trials for each task were performed in one session. In all except the control and ON tasks, a fixed point (+) was first presented with a beeping sound and after 500 ms a test pattern was presented. The pattern changed after a random time from one to four seconds had passed. In the ON task, the test pattern was not shown at first. In the control task, only the green edge instead of the test pattern was shown at first. The observer responded to changes of test pattern by pushing a mouse button quickly. The trials for each condition were repeated 10 times in random order in one session of each task except for the control task. Each observer carried out 80 trials for each of the ON and OFF tasks and 60 trials for each of the STM and MTS tasks, and 120 trials for the VC task. The trials in the control task were repeated 30 times.

Results

The mean response times for each condition in each task are shown in Figure 3. The results are summarized as follows. (1) The mean response time in the control task was 270 ms. (2) The mean response time in the ON and OFF tasks was about 300 ms. No difference between these two tasks, nor any influence of velocity, was observed. (3) The mean response times for the STM and MTS tasks were longer that those for the ON and OFF tasks. Moreover, the response times decreased with velocity in both the STM and the MTS tasks. (4) In the VC task, response times were longer in the accelerated condition than in the decelerated condition. However, no consistent tendency dependent on velocity difference was observed.

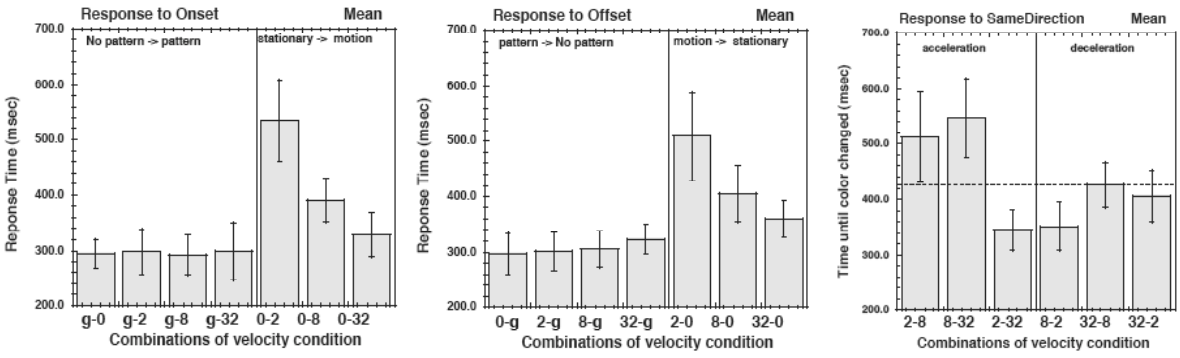

Fig.3. The results of Exp. 3 (Simple response time). The number in velocity condition indicates the velocity (deg/s) but g indicates no (gray) pattern.

General discussion

Almost identical results were obtained for the ON and STM tasks in three experiments. Detection of change in the ON task was faster than in the STM task, and in the latter task the detection time decreased with velocity. We can say that these results are consistent.

On the other hand, the results for the OFF and MTS tasks were different among experiments. There was no influence of velocity in the OFF task in any experiment. However, in the OFF task in Experiment 1, changes of test pattern were perceived almost simultaneously with changes of color, while in Experiment 2 these were perceived before the changes of color. As for the MTS task, in Experiment 1 changes of pattern were, in contrast, perceived before changes of color, while in Experiment 2 these were ambiguous. Accordingly, detection in the OFF task was faster than in the MTS task in Experiment 1, whereas the opposite result was found in Experiment 2. In Experiment 3, influences of velocity were not observed in the OFF task but were clearly observed in the MTS task. Detections in the OFF task were faster than in the MTS task. Therefore, the results were the same as in the ON and STM tasks and somewhat similar to those in Experiment 2.

When considering why opposite results for the OFF and MTS tasks were obtained in Experiments 1 and 2, the methodological difference between the experiments should be taken into account. The results of Experiment 2 may have been distorted because the temporal conditions for Experiment 2 were chosen based on the detection times obtained in Experiment 1. However, if this is true, the same distortion may have also occurred in the ON and MTS tasks. Although the results in Experiment 3 were similar to those in Experiment 2, there is a little difference between them. While the detection time for velocity combination of 2–0 deg/s was the minimum in the MTS tasks of Experiments 1 and 2, it was the maximum in Experiment 3. This difference might reflect a difference in the process related to judgments.

The results for the VC task were consistent in all experiments. Detection was faster in the decelerated condition than in the accelerated condition. However, the influence of velocity was not consistent. Although detection in the accelerated condition became faster as the difference between velocities in Experiments 1 and 2 increased, the results were different from those in Experiment 3. Consistency of results in the decelerated condition among experiments was not obtained. This inconsistency might be based on the methodological difference between TOJ in Experiments 1 or 2 and response times in Experiment 3.

Particularly inconsistent results were found in the OFF and MTS tasks. Although this inconsistency between experiments may be attributable to the methodological difference or the different processes related to judgments, we can also consider it an experimental error or artifact, because there is little methodological difference between Experiments 1 and 2. We should distinguish them clearly in a future study.

Acknowledgments

The author thanks Ms. Sakiko Urita for technical assistance.

References

Mateeff, S., Dimitrov, G., & Hohnsbein, J. (1995). Temporal thresholds and response time to changes in velocity of visual motion. *Vision Research*, *35*, 355-363.

Mateeff, S., Genova, J., & Hohnsbein, J. (1999). The simple response time to changes in direction of visual motion. *Experimental Brain Research*, *124,* 391–394.

Hohnsbein, J., & Mateeff, S. (1992). The relation between the velocity of visual motion and the response time to motion onset and offset. *Vision Research*, *32*, 1789-1992.