Temporal precision in visual perception and impression formation in active observation

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We investigated how the temporal precision of the visual processing related to the impression formed in conducting active or passive observation of the visual stimulus and experimental tasks. In the experiment, we measured the extent of the flash-lag effect as an index of the precision in visual processing, and impression on the stimulus for each of five observing conditions, which were defined in accordance with the levels of active commitment of the observer to the stimulus motion, including active and passive observation conditions. Eight naïve observers consistently distinguished those conditions in terms of the impression formed in the observation. We found that the extent of the flash-lag effect decreased with the increment of the rated scores on the controllability of the visual stimulus while there was no significant correlation between the extent of the flash-lag effect and the rated scores in the other scales, such as confidence of the precision in the perceptual task, visibility of the stimulus, tightness in the connection between hand movement and stimulus motion, and wrongness felt in conducting the task. These results suggest that observers' mental set that they can actively control the situation of the stimulus has unique and robust effects to improve the temporal precision in the visual processing.

Key words: *Flash-lag effect, Active observation, Impression formation, Mental set, Controllability*

Introduction

This study uses the flash-lag effect (Nijhawan, 1993) to investigate the effects on visual perception and impression formation of observer's active control of visual stimulus. In previous studies, we reported that observer's actively manual control of the visual stimulus (Fig. 1) would reduce the flash-lag effect in terms of advance in the temporal precision in visual processing (Ichikawa & Masakura, 2004, in press). Such a reduction of the flash-lag effect in terms of active observation was also found in the measurement of the simple reaction time. Moreover, we found that, when the stimulus moved automatically while observers believed that they controlled the stimulus movement, the flash-lag effect was reduced. In addition, we found that the reduction was restricted to the condition in which the direction of hand movement corresponded to that of stimulus movement (Ichikawa & Masakura, 2006). However, we obtained the largest flash-lag effect for the condition in which the stimulus moved automatically while observer moved the mouse that was not connected to the stimulus, and in which observers reported the strongest wrongness.

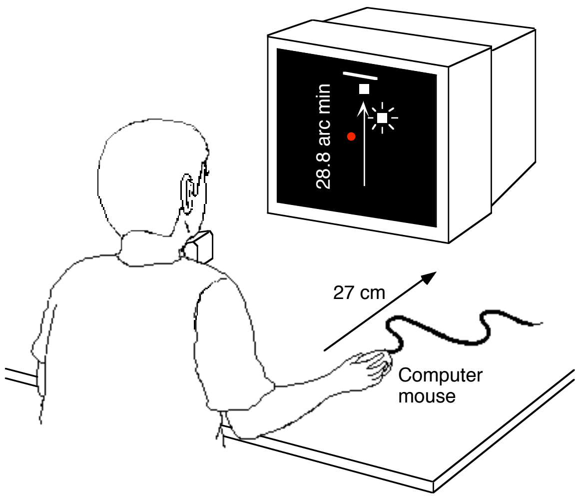

Fig. 1. Active observation of the flash-lag stimuli. A computer mouse controlled the vertical position of the moving stimulus

These results suggest that there could be some relationships between observer's feeling and temporal precision in visual processing when the observer actively conducted the task. However, in those previous studies, we did not investigate the relationship between observers' feeling and precision in visual processing.

In this study, we investigated how the temporal precision of the visual system related to the impressions formed in conducting the active and passive observations of the visual stimulus. We examined whether the visual precision linearly changed with the rating concerning with different scales that could be related to the precision in the visual processing, such as confidence, difficulty, pleasantness, satisfaction, and wrongness that they felt in conducting the observation task. In addition, we investigated the effects of the visibility of the stimulus, beauty of the image, smoothness of the hand and stimulus motion, tightness in the connection of hand movement with stimulus motion, and controllability of the stimulus.

Methods

Observers. The eight naive graduate and undergraduate students served as observers. Their age ranged from 21 to 24 years. All of them had normal or corrected to normal visual acuity. They had used personal computer with a computer mouse for at least four years. Although one of the observers was left handed, all of them used their right hand in everyday operation of their personal computer.

Stimulus and Apparatus. A personal computer (Apple Macintosh G4) presented stimuli on a 21" display (Eizo T962, 75 Hz). The viewing distance was about 50 cm. The observer sat on a chair in front of a desk (80 cm in height), with the head fixed on a chin rest, and grasped the computer-mouse with the right hand, where they could move it on the desk. A computer keyboard was placed at the observers' left hand. The mouse and keyboard were connected to the computer by USB cables.

A red square (19.1 x 19.0 arc min) as a fixation point was presented at the center of the display on a black background (1.0 cd/m^2). A white horizontal line (334.3 X 2.4 arc min, 87.6 cd/m^2) was presented at the bottom or top of the display (about 15 arc deg above or below the fixation point) as the goal line for the moving stimulus. The moving stimulus and flash stimulus were white squares (19.1 x 19.0 arc min, 87.6 cd/m^2). The moving stimulus went upward or downward along a linear course at 2.6 arc deg right or left of the vertical centerline of the display. The length of the movement trajectory for the moving stimulus was 28.8 arc deg. The vertical position lag between the moving stimulus and the flash was –76.0, 0, or 76.0 arc min (negative or positive values indicate that the position of the flash was behind or ahead of the moving stimulus, respectively). There were three possible positions for the flash, and it ranged 4.5 to 7.0 arc deg above (for the upward movement) or below (for the downward movement) the fixation point.

Procedures. We measured the extent of the flash-lag effect and impression on the task with five observing conditions that would give different impressions in the dimensions of controllability and evaluation. a) Active condition. Observers controlled the stimulus movement by a computer-mouse. b) Passive condition. Observers viewed the automatically moving stimulus without any operation of the computer mouse. In order to prevent the observer's feeling that they control the stimulus motion, the moving stimulus started move with random interval (ranging from 1.0 to 2.0 sec) after the observer pressed the start key. c) Half-active condition. While, at the beginning of a trial, observers controlled the stimulus movement by the use of mouse, the stimulus moved automatically at a constant velocity after it passed the center of the movable range of the stimulus (None of the observers noticed that the stimulus moved automatically when the flash was presented). d) Hand-triggering condition. With moving the mouse as in the other conditions, observers viewed the automatically moving stimulus whose movement was triggered by the initial mouse movement. e) Accompanied-hand-motion condition. Observers moved the mouse to follow the automatically moving stimulus.

The trials for these conditions were divided into five blocks. Observers completed the blocks for the Active condition first to get the average velocity for each observer. In the other conditions, the velocity of the automatic movement of the visual stimulus was fixated at the averaged velocity from the whole trials in the Active condition.

In each trial, observers estimated the lag in the vertical dimension between the moving stimulus and flash stimulus, and reported the confidence in the estimation by percent. Then, they rated by the use of seven degrees how they felt in five scales (visibility of the stimulus, beauty of the image, and smoothness of the stimulus movement). In addition, after they finished the block of each condition, they rated their impressions for that condition by the use of seven degrees in five scales (difficulty, pleasantness, satisfaction, wrongness, tightness in the connection of hand movement with stimulus motion that they felt in the execution of the task, and controllability of the stimulus).

Results

In order to evaluate the extent of the flash-lag effect in each observing condition, we used the average of the estimated lag for the condition in which the flash and moving stimuli were at the same vertical level. Because there were large individual variances in the range of the estimation, we standardized each individual data by the use of average and standard deviation.

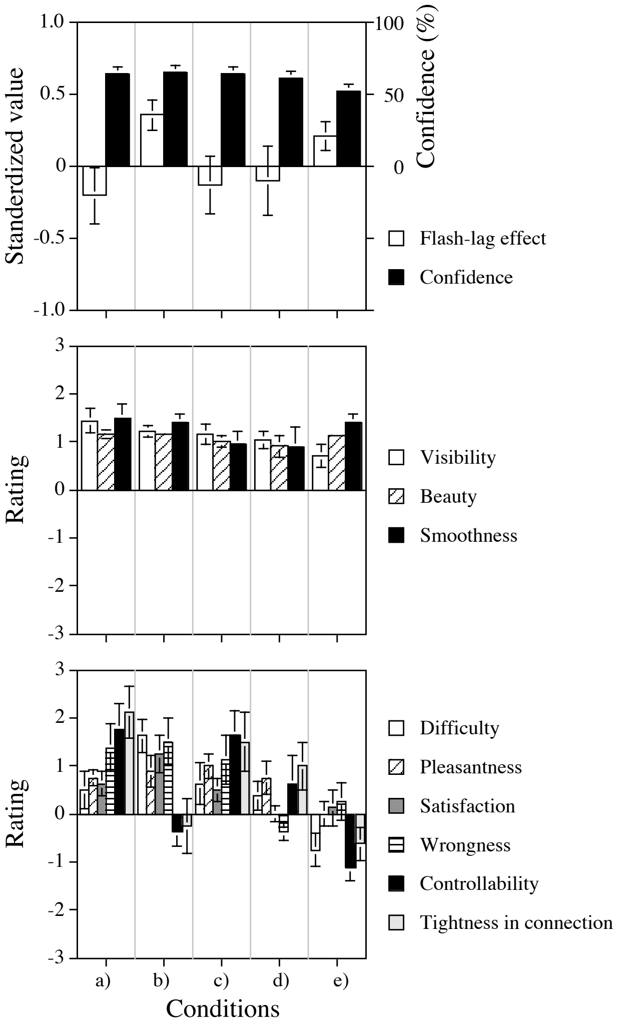

Fig. 2. Averages and *SE* from eight naïve observers for each scale.

We conducted repeated measure of ANOVA with observing conditions as factors to examine whether the standardized average of the flash-lag effect and ratings in each scale varied with the observing conditions (Fig. 2). Although the top panel in Fig. 2 shows that the largest flash-lag effect was obtained in the Passive condition, there was no significant main effect of the conditions [$F(4, 28) = 1.491$, $p > .10$]. We found significant main effects for the scales of confidence [$F(4, 28) = 3.649$, $p < .05$], difficulty [$F(4, 28) = 7.708$, $p < .001$], satisfaction [$F(4, 28) = 2.733$, $p < .05$], wrongness [$F(4, 28) = 3.971$, $p < .05$], controllability [$F(4, 28) = 6.162$, $p < .001$], and tightness in connection of hand movement with stimulus motion [$F(4, 28) = 5.335$, $p < .01$] while there was no significant main effect in the other scales. In post hoc HSD tests, significant differences were found mainly between the Active, or Half-active conditions and Accompanied-hand-motion conditions (controllability and tightness in the connection), between Passive and Hand-triggering conditions (satisfaction, and wrongness), and between the Accompanied-hand-motion and Active, Half-active, or Passive conditions (confidence, difficulty, and pleasantness).

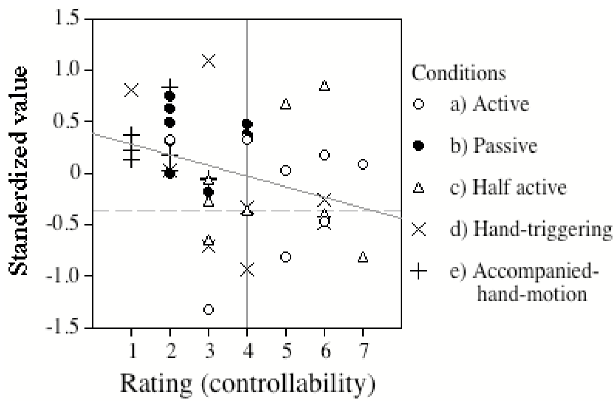

Fig. 3. Regression of the standardized values of the flash-lag effect to the rating in the scale of controllability of the visual stimulus. Data from eight observers for five observing conditions. Symbols above the horizontal dotted line, which indicates the level of the flash, imply positive flash-lag effect.

We examined whether the regression of the standardized flash-lag data to the rating data with different scales. We found significant negative correlation between the average and rating only for the scale of the controllability (r = -0.333, N = 40, $p < .05$). That is, the flash-lag effect decreased with the increment of the impressions in controllability and pleasantness of the tasks (Fig. 3).

Discussion

Our results showed that there was significant correlation between the extent of the flash-lag effect and the rating in the controllability of the visual stimulus. In addition, interestingly, there was no significant regression between the extent of the flash-lag effect and the rating in terms of the other scales, such as pleasantness and wrongness felt in each condition. Noguchi and Rentschler (1999) reported that the significant positive correlation between the rating in the scale of beauty and the extent of geometrical illusions, such as Oppel-Kundt illusion, and Botti grids. In the present results, we found no significant correlation between the extent of the flash-lag effect and the rating for the scales that would be related to the dimensions of evaluation (Osgood, Suci & Tannenbaum, 1957), such as pleasantness, beauty, and wrongness. This result indicates that the positive correlation between the scores in the dimension of evaluation and extent of the illusion cannot be generalized for the whole illusions, but it depends upon the type of illusion. In viewing the geometrical illusions that Noguchi and Rentschler (1999) used, observer might be aware what is the illusion. In contrast, in observing the stimuli which induce the illusory flash-lag effect, observer would have no awareness on what is the illusion. Awareness on what is the illusion could be necessary condition for the correlation between the rating in the dimension of evaluation and the extent of the illusion.

Our present study showed that the extent of the flash-lag effect decreased with the increment of the rating in the scale of the controllability of the visual stimulus. While observers' ratings in terms of the other impression scales varied with observing conditions, those variances in the impressions looked independent of the precision in the visual processing. It is surprising that there was no significant correlation between the flash-lag effect and the confidence of the estimation, or difficultly of the task while the judgment as to controllability of the stimulus showed significant negative correlation. These results suggest that the temporal precision in the visual processing would depend upon the observers' mental set that they can actively control the situation of the visual stimulus. This notion is compatible with the previous finding that the flash-lag effect was reduced in the Half-active condition (in which, in fact, the stimuli automatically moved independent of the observers' mouse control when a flash was presented) as well as in the Active condition (Ichikawa & Masakura, 2004, in press). Perceptual processing in the active observation, which has not been investigated in psychological studies, could be different in many aspects from that in the passive observation that has been investigated in many past psychophysical studies. In particular, the mental set of the controllability of stimulus, which are involved in active observation, affect the precision in the perceptual processing. In order to achieve comprehensive understanding of the perceptual and cognitive system of human, in particular in daily life situations in which people commit themselves to active observation, future studies should investigate how this mental set of active controllability of the stimulus affects the processing in various perceptual aspects in vision (for example, motion, shape change, and so on) as well in the other perceptual modality, such as in audition.

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