A reversal of illusory offset between two kinds of motion stimuli by a longer ISI

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Motion-defined motion (MDM) is the motion of patterns defined by local movement direction. Motion- and luminance-defined motions (LDM) are perceived as misaligned when they are presented physically with the same speed and in phase (the perceptual offset phenomenon, POP). In this study, we examined the effects of ISIs (inter-stimulus intervals) that were introduced between pattern motion frames of the POP. When an ISI was introduced to MDM, the estimated offset decreased rapidly as the ISI increased from 0 to 80 ms. Furthermore, when the ISI was 80 ms most subjects reported offsets in the reverse direction. These results indicate that simple differences in the transduction latency for MDM and LDM cannot explain the POP.

Key words: vision, motion perception, second-order motion, perceptual offset

Several studies have reported perceptual errors in the position of moving objects (e.g. the flash lag effect, Nijhawan, 1994). We have reported a perceptual offset phenomenon (POP) as one such illusion (Maruya & Sato, 2003). In this illusion, gratings defined by different attributes were perceived to be misaligned when they were presented physically with the same speed and in phase (Figure 1a). By using the same methods as our previous study, we examined the effect of introducing an ISI on this illusion to explore the origin of the phenomenon. An ISI has often been used as a procedure to disturb early motion systems which are based on motion energy (Adelson & Bergen, 1985; Georgeson & Harris, 1990; Braddick, 1974). By utilizing this procedure, we investigated how the POP varied when a critical change of early motion processing occurred.

Method

In this study, we used a luminance-defined motion (LDM) and a motion-defined motion (MDM, cf. Zanker, 1993) as two types of motion stimuli. The stimuli were two types of square wave patterns. Each of them consisted of 1024 random dots in a stimulus field of $120 \times 300$ pixels, which corresponds to a visual angle of $4 \times 10$ deg. Square-wave patterns were generated by modulating the movement direction of dots (up or down; motion-defined motion) or their luminance (luminance-defined motion). The spatial frequency of the modulation was 0.2 c/d for both the MDM and LDM. For LDM stimuli the dots were static. For MDM stimuli the dots were shifted by 8 arc min every 20 ms. The MDM and LDM stimuli were generated by shifting these square waves pattern every 120 ms by a 30 deg phase angle. The MDM and LDM patterns were moved at the same speed, and phase misalignments between the two stimuli were measured by using the method of constant stimuli. The physical phase offset was varied in eight steps between 12 and $-12$ deg phase angle. The MDM stimuli were presented 2.5 deg above a fixation point and the LDM stimuli were presented 2.5 deg below. In conditions where an ISI was introduced either the luminance- or motion-defined patterns disappeared for a given time. This was achieved by making the luminance of the dots uniform (for LDM) or by making the local motion direction random (for MDM). An ISI was introduced for either the LDM or MDM stimuli, and varied in five steps from 0 to 80 ms.

The task of the subjects was to discriminate an
offset direction by using the 2-AFC method. The experiment was conducted in sessions with a fixed ISI. Each block had 160 trials, and within blocks, eight offset conditions were presented 20 times in a randomized order. The subjects performed 2 blocks for every shift condition.

Results and discussion

We calculated the rate of the responses for LDM being ahead of MDM as a function of physical offset in each condition. After that, the null point for the apparent offset was calculated for these data with a probit analysis. The means of the perceptual offset of five subjects are plotted as a function of ISI in Figure 1b. When an ISI was introduced for the LDM stimuli the offset was virtually constant. In conditions where an ISI was introduced for MDM stimuli, the offset rapidly decreased as the ISI increased from 0 to 60 ms. When the ISI was 80 ms, all of the subjects perceived an illusory offset in the reverse direction to that perceived in the other conditions. In normal conditions when the ISI was 0 ms, the LDM was perceived to be before the MDM. However, the LDM was perceived to be after the MDM when the ISI was 80 ms.

This decrease and reversal of perceptual offset indicates that a simple difference in transduction latency between MDM and LDM cannot explain all aspects of the POP. Frame onsets of pattern motion occurred at the same time regardless of the length of the ISI, and the difference in the latency should be constant for the ISI conditions. If a latency difference was a cause of the POP, the ISI should not have influenced the POP. The current results are obviously inconsistent with this prediction.

One explanation for the reduction and reversal of the POP is that a critical change may occur to a position processing of moving objects through introduction of an ISI. In our pilot study, MDM was perceived to be faster than LDM for the same conditions we used in the present investigation. According to this, if the perceived speed difference was integrated in some temporal window, the MDM should be before the LDM. The current results were consistent with this prediction. We reported that such a perceived speed difference did not explain the POP. However, it is possible that a critical change occurred to the flow of information in position processing by the introduction of an ISI. The ISI could then cause an absence of fundamental frequency-based information and influence higher-order information.

References


