Effects of envelope motion and carrier motion in Gabor patch on perceived position

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De Valois and De Valois (1991) showed that individuals perceive a shift in the position of a static Gabor patch with a moving carrier in the direction of motion inside the stimulus. In our previous study, we showed that illusory position shifts were induced in the direction of carrier motion on the retina. Here, we investigate the effects of envelope motion on the display and examined position shifts when the envelope and carrier moved independently. The results revealed that the envelope-relative motion rather than the display-relative motion induced illusory position shifts.

Key words: illusion, position perception, visual motion perception

The precise neural mechanisms that allow us to detect the position of an object are still relatively unknown. In psychological studies, the perceived position of a static object is affected by motion inside that object. De Valois and De Valois (1991) showed that carrier motion in a static Gabor patch induced a shift in the perceived position of the entire stimulus. Indeed, a number of studies have used various types of motion to induce an illusory position shift: carrier motion defined by binocular correlation (Murakami & Kashiwabara, 2009), and carrier motion of a plaid pattern (e.g. Hisakata & Murakami, 2009). Previous studies, however, have not investigated the effects of envelope motion on perceived position.

We previously showed that retinal carrier motion induced an illusory position shift when the envelope moved in the same direction at same speed as the eyes (Hisakata, Terao, & Murakami, 2010). In the current study, we examined whether envelope motion affects the perceived position of an object and whether envelope motion and carrier motion interact. We measured illusory position shifts while the envelope and carrier moved independently.

Methods

The subjects for this study included one of the authors and seven naïve adults with normal vision. The stimuli were two vertically arraigned Gabor patches (Fig. 1) presented on a cathode ray tube monitor (1 min/pix; refresh rate, 100 Hz). The upper and lower images contained a static horizontal carrier and a vertical carrier that moved at various velocities. After the lower Gabor stimulus was presented for 750 ms, the upper Gabor stimulus was presented for 250 ms. The experimental conditions were characterized by a static envelope or a moving envelope. Under the static envelope condition, the envelopes of both the upper and lower Gabor patches were static. The carrier in the lower Gabor patch moved at 2.5–5 deg/s. Under the moving envelope condition, both envelopes moved at 2.5 deg/s in the same direction (Fig. 1). In this case, we assessed display-relative or envelope-relative carrier velocity. The display-relative velocity was determined based on the carrier grating moving on the display: −0.5 to 5.5 deg/s (a negative velocity indicated that the carrier and envelope moved in opposite directions). The envelope-relative velocity was determined based on the movement of the grating relative to that of the envelope, and was calculated by subtracting the envelope velocity from the display-relative velocity: −3 to 3 deg/s. To investigate perception of the relative positions of moving objects, a control condition was used in which both upper and lower Gabor patches were characterized by a static horizontal carrier.

We measured illusory position shifts using con-
disturbant methods. Subjects were asked to judge whether the upper stimulus was to the right or left of the lower Gabor patch.

Results

Figure 2a shows averaged positional shifts across subjects under the condition in which the envelope was static. We confirmed the illusory shifts in this experiment. The illusion saturated at 2.5 deg/s.

Figure 2b (upper panel) shows averaged positional shifts under conditions in which the envelope moved. The lower axis indicates the envelope-relative velocity, whereas the upper axis indicates the display-relative velocity. Under the control condition, an illusory shift occurred even though the two carriers did not move. This likely reflected positional shifts caused by temporal differences between the upper and lower Gabor patches, similar to flash-lag effects. To extract positional shifts only by stimulus motion, we subtracted the shift from the other data (Fig. 2b, lower panel). The illusion was related to the envelope-relative motion, not the display-relative motion. Furthermore, we found that the magnitude of the position shifts decreased when the carrier and envelope moved in the same direction, compared with conditions in which they moved in opposite directions (comparison of absolute values: F(4, 20) = 3.66, p < 0.05).

Discussion

In this study, we showed illusory position shifts in the direction of carrier motion relative to the envelope, even if the envelope of the stimulus moved. We also found that the magnitude of the illusory shifts decreased when the envelope and carrier moved in same directions. These results suggest that the position of a stimulus is primarily estimated based on the contour position and this estimation is biased by motion inside the stimulus object. In addition, the estimated position of the object is disproportionately opposite to the direction of contour motion because the future stimulus position is unknown.

References


