Backdrop motion illusion from images of a walking human figure

Kiyoshi FUJIMOTO*,** and Takao SATO***

University of Tokyo* ***

We have found a novel visual illusion where an ambiguous motion became unidirectional with the superimposition of an image of a human figure walking on a treadmill. When we presented a counterphase grating as an ambiguous backdrop, the grating appeared to drift in the opposite direction to the bipedal locomotion. This phenomenon indicates that the visual system would evaluate low-level motion signals relative to a high-level representation of an object's movement defined by its biological motion. In this study we presented images of human figures either walking forward or walking backward in order to examine the effects of a directional correspondence between human movement and form that was important for the recognition of biological motion. The results revealed that a forward walker produced the illusion more reliably than a backward walker, and confirmed that recognition of locomotion is a primary determinant for the illusion.

Key words: visual illusion, motion perception, biological motion

Current models of motion perception attempt to explain how the visual system estimates the movement of an object from retinal flow (Lu & Sperling, 2002). However, the visual system is also capable of representing the movement of an object even if an object retains a fixed position on the retinas when the eyes are stationary. For example, the translation of a walker is recognized solely from the articulated movements of the limbs.

Our investigations demonstrate that such a high-level representation of human movements is so powerful that it can modulate low-level motion processing so that an apparent motion in a background pattern is induced. In order to explore this phenomenon we have designed movie clips in which the image of a walking human figure is superimposed on a counterphase grating (Figure 1). The grating is the sum of two gratings moving at an equal velocity in opposite directions. This grating is usually perceived as a directionless flicker, which indicates a non-biased integration of the two directional signals extracted in the earliest motion processing. However, when an image of a walking human figure is superimposed on the counterphase grating, the grating appears to be unidirectional, as though a striped wall was moving relative to the stationary walker (for demonstrations of this illusion, visit http://www.1.u-netsurf.ne.jp/iff/gait/).

In the present study we have examined the effects of a directional correspondence between human movement and form by using an image of a human walking in either of two ways: forward or backward. The backward walker faced in the opposite direction to locomotion. If the form were critical, the perception of the direction of the grating movement would be opposite to the direction the figure was facing, namely, in the same direction as the backward

* Intelligent Modeling Laboratory, University of Tokyo, 1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657
** Present address: Life Electronics Laboratory, National Institute of Advanced Industrial Science and Technology, 1-8-3 Midori-ga-oka, Ikeda, Osaka 563-8577
*** Department of Psychology, Faculty of Letters, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033

Figure 1. Movie clips of the backdrop motion illusion. If the person is walking toward the left, the grating appears to drift toward the right.
walking.

Method

Apparatus. Visual stimuli were displayed on a color CRT monitor by using an Apple PowerMacintosh. A gamma correction was applied to produce luminance linearity. Each observer viewed the display binocularly from a distance of 90 cm while their head was supported by a headrest. The experiment was conducted in a dark room.

Stimuli. The images of human figures walking on a treadmill were designed with Curious Labs Poser 4 software. The figures faced either left or right, and they subtended 2.9 × 1.2 degrees of visual angle in height and width, respectively. The walkers completed one step-cycle in a period of 1.2 seconds.

The image of each human figure was superimposed on a sinusoidal counterphase grating that subtended 5 degrees of visual angle in both height and width. The spatial and temporal frequencies were 4 cycles per degree and 8 Hz, respectively. The luminance contrast was 60% and the mean luminance was 30 cd/m². The luminance contrast was multiplied by a 2-D Gaussian envelope with a standard deviation of 1 degree of visual angle. The stimulus was presented in a uniform gray field with the mean luminance of the grating. The stimulus duration was 0.48 seconds.

Procedure. Eleven observers were asked to report their perceptual impressions of the grating with a forced choice of three alternatives: flickering, drifting left, or drifting right. The two directional responses were classified as an "opposite response" or a "same response" according to their relationship to the walking direction. Each participant observed, and reported on, 16 trials in which the figure walked forward and 16 trials in which the figure walked backward.

Results

For the forward walker, the opposite response was obtained for 67.1% of the trials, the same response for 51.1% of the trials, and the flicker response for 27.8% of the trials. For the backward walker, 38.6% of the responses were the opposite response, but 36.4% were the same response and 25.0% were the flicker response. Analysis of the data with two-tailed t-tests indicated that the opposite response for the forward walker occurred significantly more often than the opposite response or the same response for the backward walker, t(10) > 3.25, p < .01.

Discussion

The forward walker induced an apparent motion of the grating in a direction opposite to the walking with the high probability. On the other hand, images of the backward walker induced apparent motion in the opposite and same directions with the equal probabilities, and the percentages were significantly lower than that for the opposite response for the forward walker. These results indicate that a correspondence of direction between human motion and form is critical for the illusion. This is consistent with a recent model of biological motion recognition, assuming that the recognition is achieved by a cooperation between motion and form processing (Giese & Poggio, 2003). Learning also contributes to the recognition, and this may account for the ambiguous results from the backward walker. Backward walking is rarely encountered in everyday life.

Our findings could impact on the current models of motion perception as follows. First, low-level motion signals could be modulated relative to a high-level representation of object motion which is defined by biological motion. Second, such modulation effects extend to a relatively large visual field over the area in which the object motion is represented. The percept reflects a scene that is frequently experienced in everyday life. Thus, our findings suggest the existence of a scene-based modulation of motion signals by a high-level perceptual inference.

References
