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# Configurational coincidence among six phenomena: A comment on van Lier and Csathó (2006)

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**Abstract.** This study focuses on a configurational coincidence among six different illusions, two being motion illusions (reversed phi movement and phi movement), two being binocular stereo effects (Anstis – Rogers type and Gregory – Heard type), one being a position illusion (Gregory – Heard illusion), and one being an orientation illusion (Café-Wall-like tilt illusion). The stimuli of these six illusions or effects share the same configuration, in which a thin region is flanked by thick regions of different luminances. A phenomenological comparison is conducted with the use of dynamic demonstrations as well as static ones. In particular, the reversed phi movement is extensively discussed.

## 1 Introduction

There is a configurational coincidence among motion, position, stereo, and tilt illusions. The earliest reference is that by Anstis and Rogers (1975), who showed a close relationship between the reversed phi movement and a binocular stereo effect. Subsequently, Gregory and Heard (1983) investigated a motion illusion similar to the reversed phi movement and compared their motion illusion with a position illusion and another stereo effect different from that of Anstis and Rogers. Recently, van Lier and Csathó (2006) pointed out a configurational coincidence between the Gregory – Heard motion illusion and the Café-Wall-like tilt illusions. Here, I review and discuss these configurational coincidences because they might possibly include some hints for revealing unknown mechanisms underlying the visual perception of motion, position, stereo, and orientation.

### 1.1 *Motion illusion*

Reversed phi movement refers to an illusory motion in the direction opposite to the positional shift of an object (Anstis 1970; Anstis and Rogers 1975). Figure 1a shows an example, in which the right flank of the inset is always bright and the left flank is constantly dark while the luminances of the inset and surround are dynamically changing. When the luminance of the inset increases and that of the surround decreases, the inset shifts *rightward* in position accompanied by a negative-to-positive change while the perceived motion is *leftward* (animation 1).[1] Gregory and Heard (1983) found that a dynamic change of only the surround is sufficient to generate such a motion illusion. Figure 1b shows an example, in which the luminance of the inset is constant while that of the surround dynamically changes (animation 2).

Here, I tentatively combine the reversed phi movement with the Gregory – Heard motion illusion and call them the 'Anstis – Rogers – Gregory – Heard (ARGH)' motion illusion, because their phenomenal appearances are similar. In addition, Gregory and Heard (1983) mentioned that the apparent motion is also retained when the luminance of the inset dynamically changes while that of the surround is constant (animation 3). In the ARGH motion illusion, including this type, the direction of the apparent motion is opposite to that of the apparent positional displacement.

[1] In general, 'reversed phi' refers to its stroboscopic version (eg Anstis and Rogers 1986).

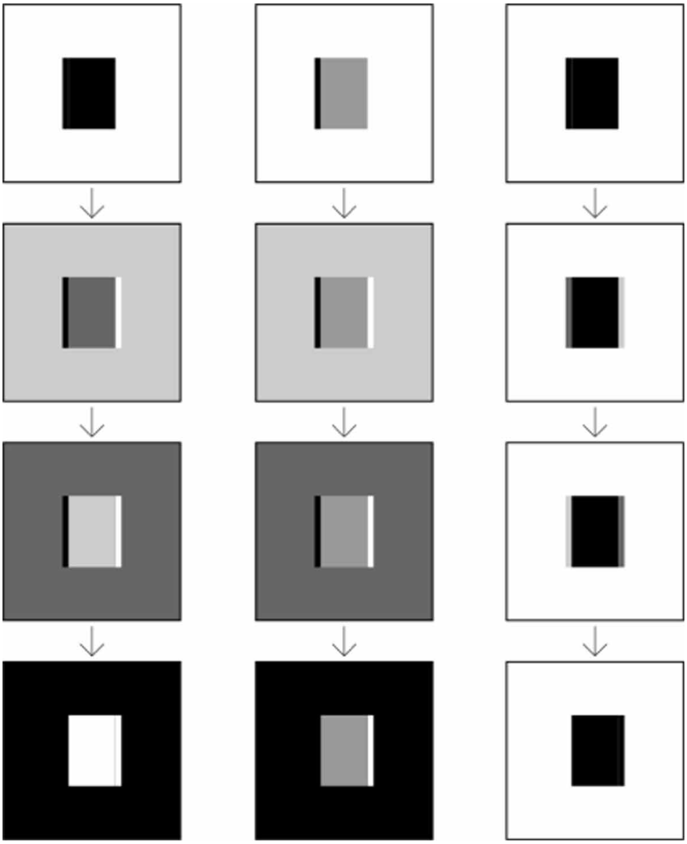



**Figure 1.** (a) Reversed phi movement (Anstis and Rogers 1975). (Note: Flash animations can be viewed on the *Perception* website at http://www.perceptionweb.com/misc/p5319b/.) The thin flanks of the inset are constant in luminance (dark or bright) while the inset changes from dark to bright and the background simultaneously changes from bright to dark. In this sequence, the perceived motion of the inset is leftward whereas the positional shift is rightward (animation 1). (b) The illusory motion investigated by Gregory and Heard (1983). The only configurational difference from the reverse phi movement is that the inset is constant in luminance. In this sequence, the perceived motion is leftward while the positional shift is rightward (animation 2). (c) Phi movement (Anstis and Rogers 1975). The inset and surround are constant in luminance while the right flank changes from bright to dark and the left one changes from dark to bright. In this sequence, the perceived motion as well as the apparent positional shift of the figure is rightward (animation 4).

Moreover, the phi movement was demonstrated in almost the same configuration by Anstis and Rogers (1975). Figure 1c shows an example, in which the luminance of the inset is always dark and that of the surround is constantly bright while the luminances of both flanks are changing. When the luminance of the right flank decreases and that of the left flank increases, the inset appears to shift rightward in position as well as in motion (figure 1c and animation 4).[2] In the phi movement, therefore, the direction of the apparent motion agrees with that of the apparent positional displacement.

### 1.2 *Position illusion and stereo effects*

Gregory and Heard (1983) discovered a position illusion. Figure 2a shows that the distance between the upper two gray rectangles appears to be larger than that between

[2] In general, 'phi' refers to the motion perception when one image abruptly shifts its position.

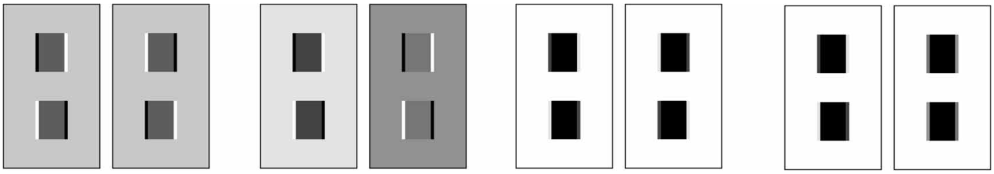

(a) (b) (c) (d)

**Figure 2.** (a) The Gregory and Heard (1983) stereogram. In the right column, the upper rectangle appears to shift rightward in position with respect to the lower one, though they are vertically aligned. In the left column, the apparent positional shift is the reversal. If observers cross-fuse (uncross-fuse) the two columns, the upper rectangle appears to be in front of (behind) the lower one. This indicates that the perceived depth agrees with the binocular disparity of the apparent positional shifts. (b) The Anstis and Rogers (1975) stereogram. In the left column, the upper rectangle appears to shift leftward in position with respect to the lower one. In the right column, the apparent positional shift is small. If observers cross-fuse (uncross-fuse) the two columns, the upper rectangle appears to be behind (in front of) the lower one. This indicates that the perceived depth disagrees with the binocular disparity of the apparent positional shifts. (c) A stereogram made up of the stimuli of Anstis and Rogers's (1975) phi movement. The apparent positional shift as well as the binocular depth perception are similar to those in panel (a). (d) An unmentioned stereogram of the stimuli of the phi movement. The configuration is similar to that in panel (b), but the perceived depth agrees with the binocular disparity of the apparent positional shifts. That is, the upper rectangle in the left column appears to shift leftward in position with respect to the lower one while the upper rectangle in the right column does not appear to shift so much, and the cross-fused (uncross-fused) upper rectangle appears to be in front of (behind) the lower one.

the lower two, though they are aligned vertically. Moreover, Gregory and Heard reported that this position illusion agrees with a binocular stereo effect. When observers cross-fuse (uncross-fuse) the rectangles in figure 2a, the upper rectangle appears to be in front of (behind) the lower one (see also animation 2). They therefore concluded that the same mechanism underlies this position illusion and this stereopsis, but that this mechanism is different from that of the motion illusion.

This conclusion conflicted with that of Anstis and Rogers (1975) who had reported a consistency between the motion illusion (reversed phi) and stereopsis. In their stereogram (figure 2b), the luminances of both flanks were the same for the right and left eyes, though they were exchanged in Gregory and Heard's (1983) paper (figure 2a). In figure 2b, there is a phase difference between the right and left columns. It is assumed that in the reversed phi movement the upper rectangle of the left column *implicitly* shifts rightward in motion with respect to the lower one, though the former appears to shift *explicitly* leftward in position with respect to the latter. When observers cross-fuse (uncross-fuse) the rectangles, the upper rectangle appears to be behind (in front of) the lower one (see also Rogers and Anstis 1975). This stereogram in motion is shown in animation 5. Anstis and Rogers (1975) then concluded that the same mechanism underlies this depth perception and the reversed phi movement, because it is the disparity of the positions expected from the reversed phi movement and not the binocular disparity of apparent positions that agrees with the perceived depth.

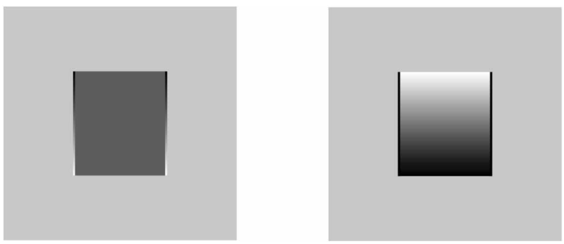
On the other hand, these three domains (motion, position, and stereo) fully agree with each other in the phi movement (Anstis and Rogers 1975). Figure 2c shows the stereogram. In the right column, the upper rectangle appears to shift rightward in position with respect to the lower one, though they are vertically aligned. In the left column, the apparent positional shift is reversed. Moreover, the direction of apparent position agrees with that of the illusory motion (figure 1c and animation 4). When observers cross-fuse (uncross-fuse) the two columns, the upper rectangle appears to be in front of (behind) the lower one. This depth perception agrees with the apparent positions as well as the positions expected from the phi movement.

In addition, when the Anstis and Rogers stereogram is applied to stimuli of the phi movement (figure 2d), the perceived depth agrees with the binocular disparity of apparent positions as well as that of the positions expected from the phi movement.

In sum, there are five illusions or effects: (i) ARGH motion illusion, (ii) phi movement, (iii) the Gregory and Heard position illusion, (iv) the Anstis and Rogers stereopsis, and (v) the Gregory and Heard stereopsis. These phenomena can be grouped into three types: the first group includes (i) and (iv) (under the condition of the ARGH motion illusion), the second group contains (iii) and (v) (under the condition of the ARGH motion illusion), and the third group covers (ii), (iii), (iv), and (v) (under the condition of the phi movement).

### 1.3 *Café-Wall-like tilt illusions*

Van Lier and Csathó (2006) pointed out a configurational coincidence between the Gregory and Heard motion illusion and Café-Wall-like tilt illusions. Figure 3 shows examples, in which the vertical flanks of the rectangle appear to tilt (Woodhouse and Taylor 1987; Roncato 2000; Roncato and Casco 2003; Kitaoka et al 2004). The idea of van Lier and Csathó (2006) is that the orientation of this tilt is consistent with the direction of the apparent motion if it is assumed that the luminance gradient implicitly changes dynamically. This point is demonstrated in animation 6.



(a) (b)

**Figure 3.** Examples of Café-Wall-like tilt illusions mentioned by van Lier and Csathó (2006). In each panel, the right vertical flank of the rectangle appears to tilt clockwise while the left one appears to tilt counterclockwise. (a) Luminance gradients are applied to both flanks. (b) Luminance gradient is applied to the inside of the rectangle.

## 2 Comments

### 2.1 *Café-Wall-like tilt illusions*

Van Lier and Csathó (2006) did not mention the relationship between (a) the Café-Wall-like tilt illusions and the Gregory and Heard stereopsis, (b) the tilt illusions and the Anstis and Rogers stereopsis, or (c) the tilt illusions and the stereopsis of stimuli for the phi movement. Figure 4a shows the first relationship, in which the tilts agree with the stereopsis; figure 4b demonstrates the second one, in which the tilts disagree with the stereopsis; and figure 4c displays the third one, in which the tilts agree with the stereopsis.

It therefore follows that, given that the luminance gradient implicitly changes dynamically, the Café-Wall-like tilt illusions are consistent with (1) ARGH motion illusion, (2) phi movement, (3) the Gregory and Heard position illusion, and (5) the Gregory and Heard stereopsis. Only (4) the Anstis and Rogers stereopsis disagrees with the tilt illusions.

However, the idea of van Lier and Csathó (2006) needs an additional explanation why it should be assumed that the dynamically changing parts are the regions of luminance gradient. If the luminance gradient is static and, instead, the other homogeneous regions are dynamically changing in luminance, the illusory motion occurs in the opposite direction to the orientation of the tilt illusions, as shown in animation 7.

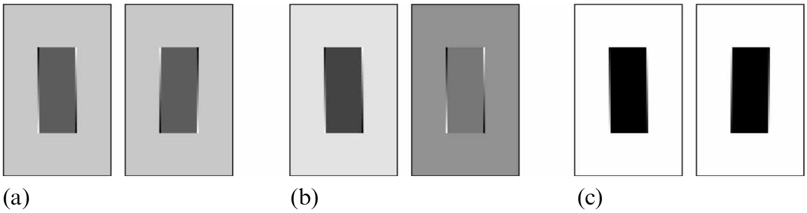



**Figure 4.** (a) A Gregory and Heard type stereogram of a Café-Wall-like illusion. The right rectangle appears to tilt clockwise while the left one appears to tilt counterclockwise. If observers cross-fuse (uncross-fuse) the two columns, the upper part of the rectangle appears to be in front of (behind) the lower part. (b) An Anstis and Rogers type stereogram of the Café-Wall-like illusion. In both columns, the rectangle appears to tilt counterclockwise. In particular, the left rectangle appears to tilt more than the right one. If observers cross-fuse (uncross-fuse) the two columns, the upper part of the rectangle appears to be behind (in front of) the lower part. (c) A phi movement type stereogram of the Café-Wall-like illusion. The apparent tilts as well as the binocular depth perception are quite similar to those in (a).

Moreover, there is another item of difficulty in their idea. The Café Wall illusion itself does not depend only on edges, but on both edges and lines (Kitaoka et al 2004). For example, the fragmented version of the Café Wall illusion (Woodhouse and Taylor 1987; Lulich and Stevens 1989; Kitaoka et al 2004) (figure 5) cannot be explained by their idea because there are no edges to be modulated.

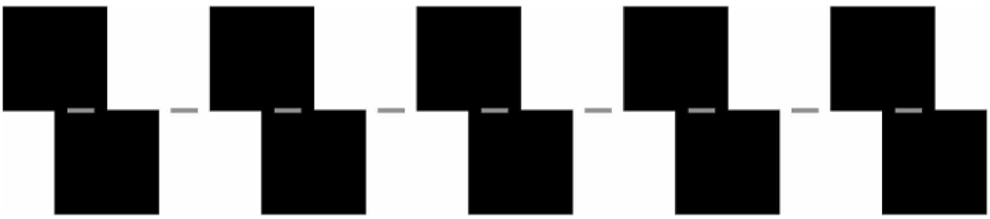


**Figure 5.** The fragmented version of the Café Wall illusion (Kitaoka et al 2004), in which the row of the fragmented horizontal or 'mortar' line appears to tilt counterclockwise.

### 2.2 *A configurational coincidence*

There is a coincidence in configuration among these six phenomena that has not been clearly noted so far. It is a special configuration with a thin region and two thick regions. The former is flanked by the latter. The ARGH motion illusion (ie the reversed phi movement and the Gregory and Heard motion illusion), the phi movement, the Gregory and Heard position illusion, the Anstis and Rogers stereopsis, and the Gregory and Heard stereopsis require the thin region to be rather narrow, eg less than 10 min of arc (Anstis and Rogers 1975; Gregory and Heard 1983). This holds true of the Café Wall illusion (Gregory and Heard 1979).[3]

I try here to hypothesize elemental spatiotemporal configurations to detect motion. There are three elemental combinations: (i) a (relatively) dark thin region flanked by a (relatively) bright thick region and (relatively) middle-luminance thick region, (ii) a bright thin region flanked by a middle-luminance thick region and a dark thick region, (iii) a middle-luminance thin region flanked by a bright thick region and a dark thick region (figure 6).

Animation 8a shows the combination (i) when the luminance of the bright flank goes up and down. When it increases, the apparent motion is directed from the bright flank to the middle-luminance flank. The apparent motion is reversed when the luminance decreases. Animation 8b shows the combination (i) when the luminance of the

[3] Furthermore, this size is also close to the maximum displacement limit ($D_{\max}$) shown in the random-dot kinematogram (Braddick 1974; Sato 1989).

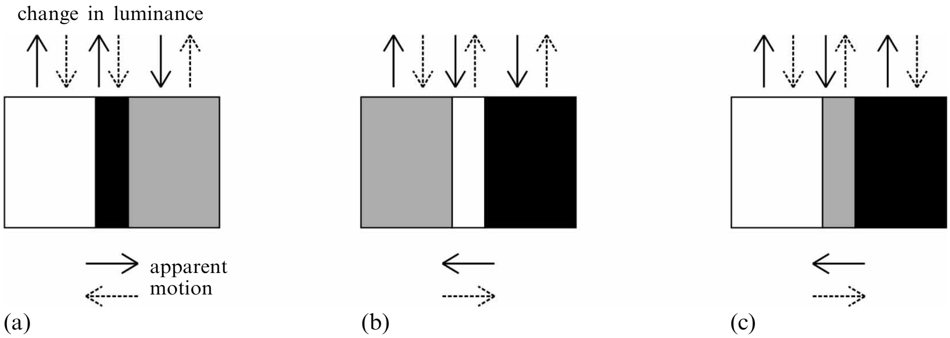



**Figure 6.** Perceived motion in the three elemental spatiotemporal configurations. Upward-pointing arrows indicate an increase in luminance in each region while downward-pointing arrows indicate a decrease in luminance in each region. Right-pointing or left-pointing arrows indicate the direction of the apparent motion. For example, when the bright region in (a) increases in luminance as indicated by the upward-pointing real-line arrow, the apparent motion is rightward as shown by the rightward-pointing real-line arrow. Panels (a) and (b) correspond to the ARGH motion illusion (eg the reversed phi movement and the Gregory and Heard motion illusion), whereas panel (c) corresponds to the phi movement. In addition, the apparent positional shift is leftward in (a) and is rightward in (b); in (c) the apparent positional shift depends on the luminance of the thin region: it is leftward when the thin region is relatively dark and is rightward when the thin region is relatively bright.

middle-luminance flank goes up and down. When it increases, the apparent motion is directed from the middle-luminance flank to the bright flank. The apparent motion is reversed when the luminance decreases. These behaviors are shown in figure 6a.

Animation 8c shows the combination (ii) when the luminance of the middle-luminance flank goes up and down. When it increases, the apparent motion is directed from the dark flank to the middle-luminance flank. The apparent motion is reversed when the luminance decreases. Animation 8d shows the combination (ii) when the luminance of the dark flank goes up and down. When it increases, the apparent motion is directed from the middle-luminance flank to the dark flank. The apparent motion is reversed when the luminance decreases. These behaviors are shown in figure 6b.

Animation 8e shows the combination (iii) when the luminance of the bright flank goes up and down. When it increases, the apparent motion is directed from the dark flank to the bright flank. The apparent motion is reversed when the luminance decreases. Animation 8f shows the combination (iii) when the luminance of the dark flank goes up and down. When it increases, the apparent motion is directed from the dark flank to the bright flank. The apparent motion is reversed when the luminance decreases. These behaviors are shown in figure 6c.

Finally, animation 8g shows the combination (i) when the luminance of the dark thin region goes up and down. When it increases, the apparent motion is directed from the bright flank to the middle-luminance flank. The apparent motion is reversed when the luminance decreases. These behaviors are displayed in figure 6a. Animation 8h shows the combination (ii) when the luminance of the bright thin region goes up and down. When it increases, the apparent motion is directed from the middle-luminance flank to the dark flank. The apparent motion is reversed when the luminance decreases. These behaviors are shown in figure 6b. Animation 8i shows the combination (iii) when the luminance of the middle-luminance thin region goes up and down. When it increases, the apparent motion is directed from the bright flank to the dark flank. The apparent motion is reversed when the luminance decreases. These behaviors are depicted in figure 6c.

Figures 6a and 6b can be regarded as the elemental spatiotemporal configurations that correspond to the ARGH motion illusion, while figure 6c can be considered the elemental spatiotemporal configuration that corresponds to the phi movement. These diagrams remind one of Hubel and Wiesel's (1962, 1968, 1977) line detectors and edge detectors, respectively. These types of apparent motion might possibly depend on some detectors that have such spatiotemporal receptive fields (cf Emerson et al 1987; Livingstone and Conway 2003). It is of interest to compare in the future these hypothesized detectors with the spatiotemporally elongated detectors that have been assumed in psychophysics and neurophysiology (Adelson and Bergen 1985; Burr et al 1986; Sato 1989; Emerson et al 1992; Conway and Livingstone 2003; Krekelberg and Albright 2005).

### 2.3 *Reversed phi movement*

Although the reversed phi movement discussed here is a smooth motion perception, 'reversed phi' generally refers to its stroboscopic version (eg Anstis and Rogers 1986; Lu and Sperling 1999). The stroboscopic reversed phi can also be explained by the activities of the assumed line-type spatiotemporal detectors (figures 6a and 6b). Let us suppose that a negative square slightly shifts to the right and changes to a positive one, as shown in figure 7. When the right edge of the square changes, the on-center line-type detector (figure 6b) is activated to produce the leftward motion information. Conversely, when the left edge of the square changes, the off-center line-type detector (figure 6a) is activated to carry the leftward motion information. Combined, the apparent motion of the square is leftward. In this explanation, the reversed phi movement depends on restricted local processes, not on the matching of contrast polarity that is somewhat more global (eg Anstis and Rogers 1986; Lu and Sperling 1999).

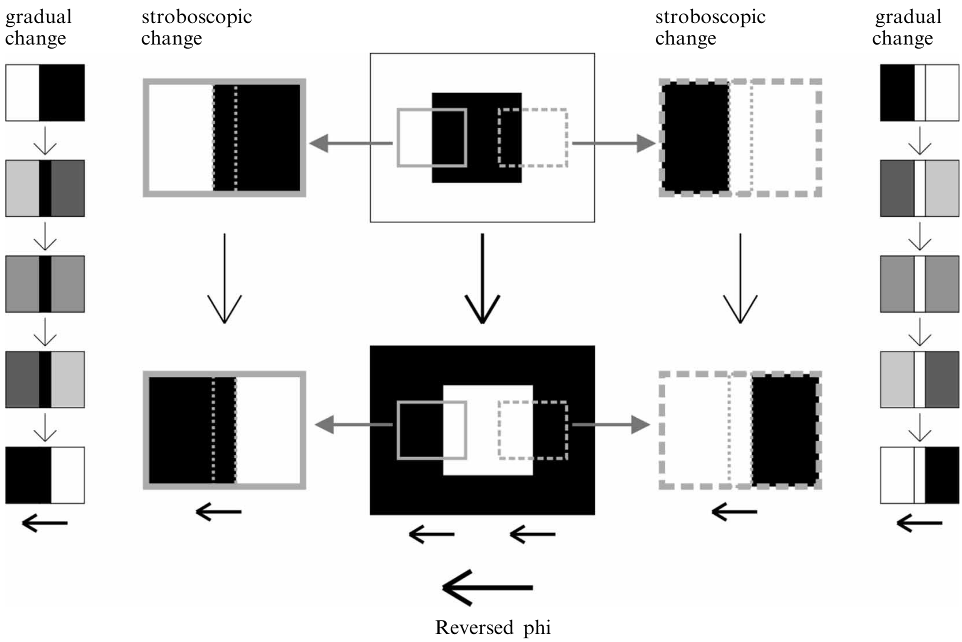



**Figure 7.** The standard reversed phi movement, which is stroboscopic, can also be explained by the activities of the assumed line-type detectors (figures 6a and 6b). In this image, a dark square on a bright background is replaced with a bright square on a dark background, with a slight positional shift to the right. When the right edge of the square changes, the on-center line-type detector (figure 6b) is activated to give the leftward motion information. Conversely, when the left edge of the square changes, the off-center line-type detector (figure 6a) is activated to carry the leftward motion information. Gray outlined (real or broken) rectangles in the middle column indicate the ranges of assumed receptive fields.

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