# Motion-illusion building blocks

Arthur Shapiro and Justin Charles, Department of Psychology, Bucknell University, USA

A number of well-known motion illusions arise when luminance modulates next to a stationary edge (e.g., Anstis and Rogers, 1975; Gregory and Heard, 1983). Here, we reduce these phenomena to four novel elemental conditions and show how these conditions can be combined (like building blocks) to generate an infinite number of new illusory configurations.

Click on the "Elemental Conditions" button in the accompanying movie. In the top two panels, the luminance of the *edge* modulates next to stationary black or white center fields; in the bottom two panels, the luminance of the *center* modulates next to black or white stationary edges (Figure 1A shows one frame of the movie). In all four conditions, the fields appear to move even though they maintain a fixed spatial position. The apparent direction of motion may seem counter-intuitive: when the luminance of a modulating *edge* is similar to the luminance of the center, the motion is *outward*, whereas when the luminance of a modulating *center* is similar to the luminance of the edge, the motion is *inward*. The direction of motion can be understood by examining the X,t plots (Figure 1B shows the X,t plots corresponding to the red circled regions in 1A—see also Johnston and Clifford, 1995, and Lu and Sperling, 1999). The motion-energy over time follows the direction of perceived motion (indicated by the red arrows). Motion would therefore be registered by a variety of motion mechanisms, as can be seen in Figure 1C, which shows the rectified output of an array of center-surround filters passed over each row of the X,t plot.

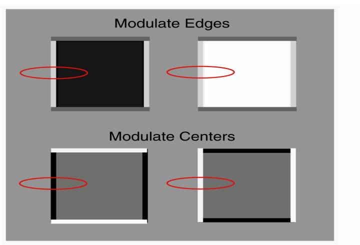


Figure 1A

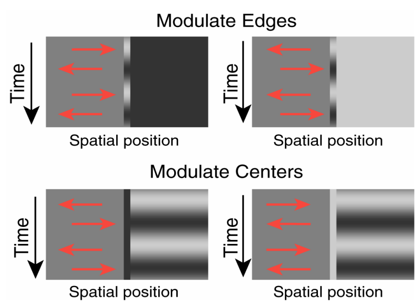


Figure 1B

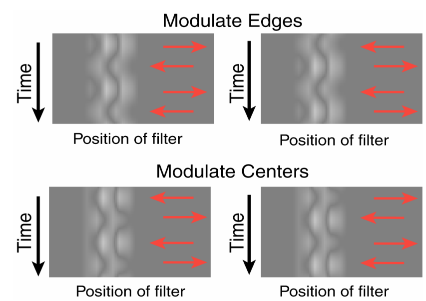


Figure 1C

We present four ways of combining the elemental conditions: *House of Cards* (center modulation), *Lucy in the Sky* (center modulation, with changes in relative phase of modulation across individual elements), *Caterpillar* (edge modulation in color, showing that the effect is determined by the luminance of the edges), and the *Tilt illusion* (center modulation, with ramped edges).

The Tilt illusion can resolve a longstanding debate as to whether such motion illusions result from X,t motion systems or sequence-tracking motion systems (see Derrington, 1985). X,t motion systems predict that motion will occur because the borders of the tilt illusion are the same as the center-modulation elemental conditions (compare Figure 2a to the bottom panels of Figure 1B). Sequence-tracking motion systems predict that motion will occur because each frame of the movie, blurred by a band-pass filter, shows distinct shifts in the position of the edge (see Figure 2B). The two models, however, predict tilt in the opposite directions: when the field and edge have similar luminance levels, the X,t motion systems predict inward motion, and the sequence tracking predicts outward motion. As would be predicted by those who claim chromatic motion is not processed in the same way as luminance motion, the equiluminant Tilt illusion follows the direction of a sequence tracking type of motion system (i.e., the motion clicks from one edge to another, opposite to the direction of the achromatic tilt illusion).

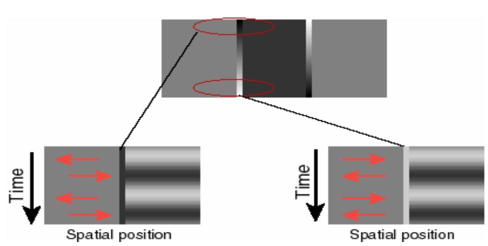


Figure 2A

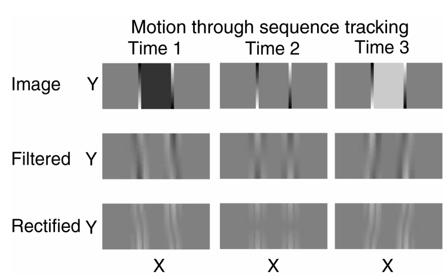


Figure 2B

Anstis, S.M., & Rogers, B.J. (1975). Illusory reversal of visual depth and movement during changes of contrast. *Vis. Res., 15*(8-9), 957-61.
Derrington, A.M. (1985). Apparent motion from luminance change: sequence discriminators see it too. *Vis. Res., 25(12), 1985-86.*
Gregory, R.L., & Heard, P.F. (1983). Visual dissociations of movement, position, and stereo depth - some phenomenal phenomena. *Quarterly J. Exp. Psych., Section a*, 35(FEB), 217-237.
Johnston, A., & Clifford, C. W. G. (1995), A unified account of three apparent motion illusions. *Vis. Res.* 35(8), 1109-23.
Lu, Z., & Sperling, G. (1999), Second-order reverse phi. *Perception & Psychophysics*. 61(6) 1075-1088.