



## Mar 30 2009 Illusions: Motion from Brightness

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Tag: [Brain](#), [camera](#), [illusion](#), [image](#), [motion](#), [object](#), [vision](#)

*How dynamic changes in brightness cause you to see movement where there isn't any*



From **Scientific American** by Stephen L. Macknik and Susana Martinez-Conde

Benjamin Franklin once said, "Never confuse [motion](#) with action." But if [motion](#) is not action, then what exactly is [motion](#)? Let's break it down.

Imagine you are pointing your video [camera](#) at your favorite ball game. Inside your [camera](#) is a lens that focuses the [image](#) onto a CCD chip, which is a matrix of light detectors. How can a matrix of light detectors possibly see a ball rolling? The answer is, it can't. The [camera](#) doesn't see [motion](#) whatsoever, because the only thing light detectors can detect is changes in light magnitude, not light position. If the edge of the ball passes over a single light detector, the detector will react, but that's trivially due to fact that the light level on the detector changed as the ball changed position. The same detector would react identically to a stationary edge that increased its brightness without having moved. To track the change in position of an [object](#), you need to add something, such as a brain, that can interpret the output of all the detectors in concert.

The photoreceptors of your retina are like the CCD chip in your [camera](#): just a matrix of light detectors. They individually respond to changes in light level, whether those changes are due to actual [motion](#) or to stationary changes in brightness. Then specialized [motion](#)-detection neurons of the brain analyze the responses from populations of photoreceptors to infer [motion](#). So although Ben Franklin may have admonished that productive activity (action) is better than unproductive activity ([motion](#)), he was also correct in the neurobiological sense: the perception of [motion](#) need not arise from a veridical action in the world. Rather, the perception of [motion](#) occurs when dedicated [motion](#) processing neurons in your brain are activated by specific patterns of light intensity changes on your retina. Because the retina cannot distinguish between the true [motion](#) of a light and the sequenced presentation of two (or more) adjacent lights, [motion](#) detectors in the brain will sometimes misinterpret certain light sequences to be [motion](#). Vision scientists call such sequences of light "apparent [motion](#)." This [illusion](#) is the basis of animation on TV or in movies.

The following pages depict several illusions in which the perception of [motion](#) arises from dynamic changes in brightness.

Now, do not to get confused and interpret action from any of these demonstrations. The [motion](#) is all in your head.

### Elemental Conditions

The outlined edges of four rectangles modulate in contrast as compared with the centers. In the top row, the centers of the rectangle are unchanging, but the top-bottom versus left-right edges modulate in counter-phase brightness, rendering the appearance of two breathing boxes. The second row proves that this effect is due to the contrast of the centers to the edges, and not to the brightness of the edges alone, because the edges are now unchanging, and only the centers of the rectangles modulate in brightness.

This [illusion](#) was first described in 1983 by Richard L. Gregory and Priscilla F. Heard, of the University of Bristol. By showing that the apparent [motion](#) is due to the shifting position of the minimal contrast between the outside of the edges versus the inside of the edges (due to either the modulation of the edges or of the center against a stable gray background), Arthur G. Shapiro and Justin P. Charles of Bucknell University won the first prize in the Best Visual Illusion of the Year contest in 2005

### House of Cards

Shapiro and Charles went further with their prize-winning entry to show that combining blocks with modulating centers could render twisting effects. When the same blocks modulate without the contrasted edges, there is no [motion illusion](#).

### Lucy in the Sky

By modulating the centers on and off with different rates, Shapiro and Charles showed that different apparent rates of [motion](#) could be attributed to different elements of the figure to create undulating shape-changing effects

### Perpetual Collisions

Shapiro and Emily Knight of Bucknell University placed in the Top Ten list of the 2008 Best Visual Illusion of the Year Contest with this variant that pits background- and edge-modulated rows of diamonds against each other in a perpetual collision that never connects.

### Steel Magnolias

Graphic designer Michael Pickard of Sunderland University built on these findings to create a spectacular artistic [vision](#) of wind-blown flowers, without a single moving [object](#).

### Bouncing Brains

Thorsten Hansen, Kai Hamburger and Karl R. Gegenfurtner of Giessen University were also top ten finalists in the 2007 Best Visual Illusion of the Year Contest, with this entry that shows that direction, magnitude and speed of apparent [motion](#) in a grid of brains depends on all three: the color of the brains, the direction of the brightness gradient of the brains as a function of the background brightness, and the retinal position of the brains with respect to the viewer's center of gaze.

Notice that if you focus your gaze at any one the brains, it moves less than the surrounding brains, and that if you step away from the screen, the brains move more than if you peer very closely at the [image](#) on the screen. Also, the relative speed and direction of the moving brains depends on their color and the direction of the brightness gradient they create with the background,

### Swimmers #7

Knight and Shapiro combined the various effects of contrast modulation, shading, shape and color to create an unmoving [image](#) of illusory but biologically plausible [motion](#), which placed among the top ten finalists of the 2007 Best Visual Illusion of the Year Contest. Notice that without the modulating background, the effect is lost.

### FURTHER READING:

Visual dissociations of Movement, Position and Stereo Depth: Some Phenomenal Phenomena. R.L. Gregory and P.F. Heard in *Quart. J. Exp. Psychol.*, 35A, 217-237, 1983.

Visual Illusions Based on Single-Field Contrast Asynchronies. A.G. Shapiro, J.P. Charles and M. Shear-Heyman in *Journal of Vision*, 5(10):2, 764-782, 2005.

The Neural Correlate Society's Best Visual Illusion of the Year Contest Web site: <http://illusioncontest.neuralcorrelate.com>.

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