May 28, 2008

The Neuroscience of Illusion

How tricking the eye reveals the inner workings of the brain

By Susana Martinez-Conde and Stephen L. Macknik

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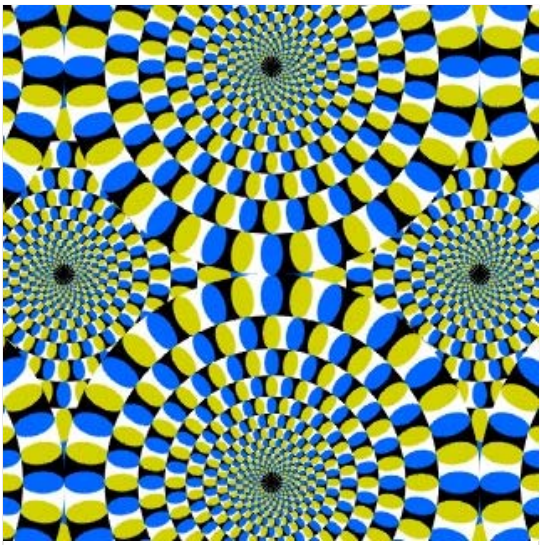

The Neural Correlate Society recently announced the winners of its annual Best Visual Illusion contest. To celebrate the event, Mind Matters *invited Susana Martinez-Conde* and *Stephen L. Macknik, two neuroscientists who specialize in visual perception, to explain the scientific value of visual illusions. This article is the first in a new* Mind Matters *series on the neuroscience of illusions.*

View a slide show of illusions

It's a fact of neuroscience that everything we experience is actually a figment of our imagination. Although our sensations feel accurate and truthful, they do not necessarily reproduce the physical reality of the outside world. Of course, many experiences in daily life reflect the physical stimuli that enter the brain. But the same neural machinery that interprets actual sensory inputs is also responsible for our dreams, delusions and failings of memory. In other words, the real and the imagined share a physical source in the brain. So take a lesson from Socrates: "All I know is that I know nothing."

One of the most important tools used by neuroscientists to understand how the brain creates its sense of reality is the visual illusion. Historically, visual artists as well as illusionists have used visual illusions to develop deep insights into the inner workings of the visual system. Long before scientists were studying the properties of neurons, artists had devised a series of techniques to "trick" the brain into thinking that a flat canvas was three-dimensional, or that a series of brushstrokes was actually a still life.

Visual illusions are defined by the dissociation between the physical reality and the subjective perception of an object or event. When we experience a visual illusion, we may see something that is not there, or fail to see something that is there, or even see something different from what is there. Because of this disconnect between perception and reality, visual illusions demonstrate the ways in which the brain can fail to recreate the physical world. By studying these failings, we can learn about the computational methods used by the brain to construct visual experience.

In the accompanying slide show, we will showcase several basic categories of visual illusions and what they can teach us about the brain.

View a slide show of illusions

Mind Matters is edited by Jonah Lehrer, the science writer behind the blog The Frontal Cortex and the book Proust was a Neuroscientist.

ABOUT THE AUTHOR(S)

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FURTHER READING

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Scientific American Reports: 105 Mind-Bending Illusions

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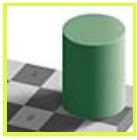
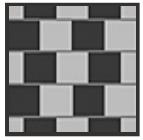
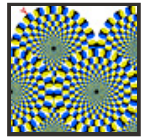

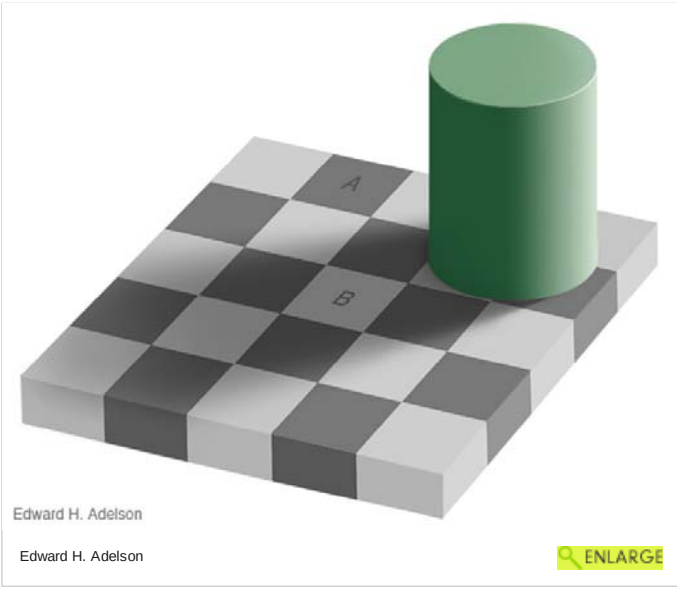

Edward H. Adelson ENLARGE

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BRIGHTNESS AND COLOR ILLUSIONS

In this illusion, created by Edward Adelson at MIT, squares A and B are the same shade of gray. (If you don't believe it, print it out and then cut out the two squares and place them side by side.) This illusion occurs because our brain does not directly perceive the true colors and brightness of objects in the world, but instead compares the color and brightness of a given item with others in its vicinity. For instance, the same gray square will look lighter when surrounded by black than when it is surrounded by white. Another example: when you read printed text on a page under indoor lighting, the amount of light reflected by the white space on the page is lower than the amount of light that would be reflected by the *black* letters in direct sunlight. Your brain doesn't really care about actual light levels, though, and instead interprets the letters as black because they remain darker than the rest of the page, no matter the lighting conditions. In other words, every newspaper is also a visual illusion!

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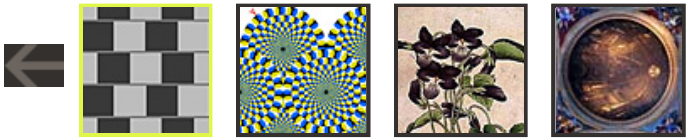

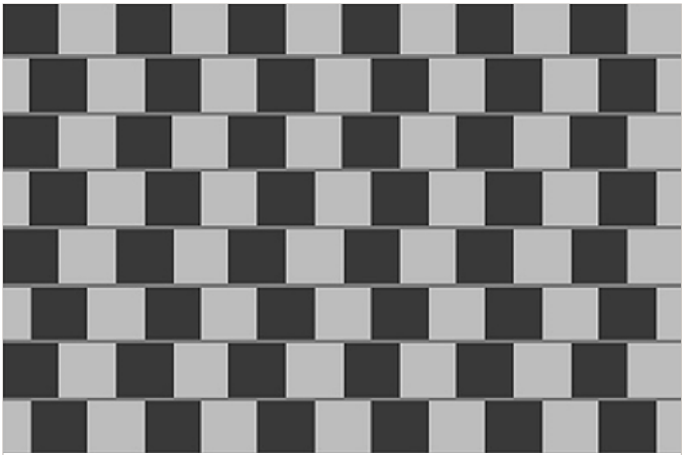

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SHAPE DISTORTION ILLUSION

This illusion is known as the Café Wall illusion, and it was first discovered by Richard Gregory's laboratory in a café in Bristol, in the U.K. The black and white tiles are perfectly straight, but look tilted. It is a shape distortion illusion: an object will appear to take on shapes that are different from its actual shape. Like brightness and color illusions, shape distortion effects are also produced by the interaction between the actual shape of the object and the shapes of nearby figures. For the brain, perception is very often dependent on context.

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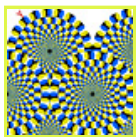

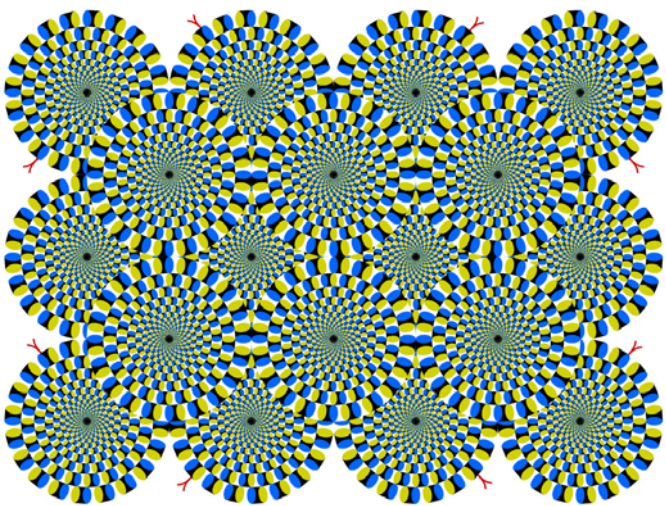

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ILLUSORY MOTION

Some stationary patterns generate the illusory perception of motion. The illusory effect is usually stronger if you move your eyes around the figure. For instance, in this illusion, invented by the scientist Akiyoshi Kitaoka, the "snakes" appear to rotate. But nothing is really moving, other than your eyes! If you hold your gaze steady on one of the black dots on the center of each "snake," the motion will slow down or even stop. Because holding the eyes still stops the illusory motion, we speculate that eye movements are required to see it. Vision scientists have shown that illusory motion activates brain areas that are similar to those activated by real motion.

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AMBIGUOUS FIGURES

This bunch of violets contains the faces of Napoleon, his wife, and their child. Can you find them among the flowers? During Napoleon's exile, his supporters used to distribute reproductions of this 1815 engravings. In such illusions, the brain interprets same picture in two different ways, with each interpretation mutually exclusive of the other. You can see one of two possible images, but never both of them at the same time. These so-called ambiguous figures are especially powerful tools to dissociate the subjective perception from the physical world. The physical object never changes, yet our perception alternates between two (or more) possible interpretations. For this reason, ambiguous illusions are used by many laboratories in the search for the neural correlates of consciousness.

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3-D ILLUSIONS

The cupola of the St. Ignatius's church in Rome is a great example of Baroque illusionism. The architect of the church, Horace Grassi, had originally planned to build a cupola, but died before finishing the church, and the money was used for something else. Thirty years later, in 1685, the Jesuit artist Andrea Pozzo (1642-1709) was asked to paint a fake dome on the ceiling over the altar. Pozzo was already considered a master in the art of perspective, but even then, the results he accomplished could hardly be believed. Even today, many visitors of St. Ignatius's are amazed to find out that the spectacular cupola is not real, but an illusion.