WHAT A TRIP

Take a visual journey through seven prizewinning illusions

By Stephen L. Macknik and Susana Martinez-Conde

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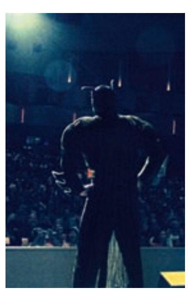


Decked out in a mask, cape and black spandex, a fit young man leaps onto the stage, one hand raised high, and bellows, "I am Japaneeeese Bat-Maaaaaaan!" in a thick accent. The performer is neither actor nor acrobat. He is a mathematician named Jun Ono, hailing from Meiji University in Japan. Ono's single bound, front and center, at the Philharmonic Center for the Arts in Naples, Fla. (now called Artis-Naples), was the opening act of the ninth Best Illusion of the Year Contest, held May 13, 2013. Four words into the event, we knew Ono had won.

Aside from showcasing new science, the contest celebrates our brain's wonderful and mistaken sense that we can accurately see, smell, hear, taste and touch the world around us. In reality, accuracy is not the brain's forte, as the illusion creators competing each year will attest. Yes, there is a real world out there, and you do perceive (some of) the events that occur around you, but you have *never actually lived in reality.* Instead your brain gathers pieces of data from your sen-

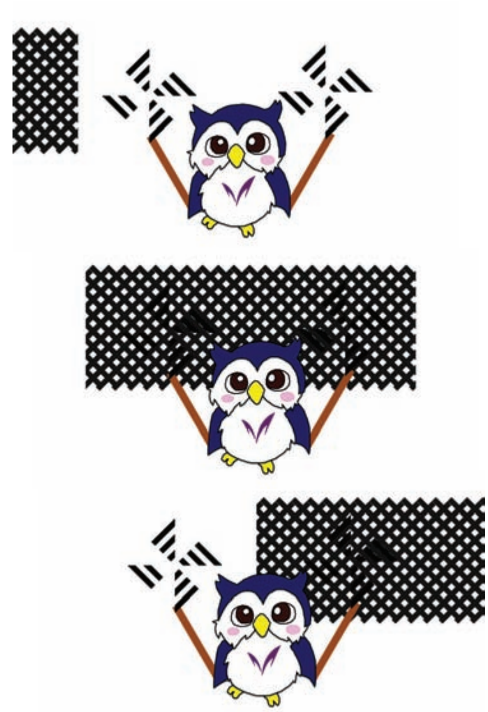
SIMONE GORI (*contestants and inset*); VICTORIA SKYE (*Batman*)

JUN ONO, AKIYASU TOMOEDA AND KOKICHI SUGIHARA *(top)*; ARTHUR SHAPIRO AND ALEX ROSE-HENIG *(bottom)*

sory systems—some of which are quite subjective or frankly wrong—and builds a simulation of the world.

This simulation, which some call consciousness, becomes the universe in which you live. It is the only thing you have ever perceived. Your brain uses incomplete and flawed information to build this mental model and relies on quirky neural algorithms to often—but not always—obviate the flaws. Let us take a spin through some of the world's top illusions and their contributions to the science of perception. (To see videos of these illusions, see **ScientificAmerican.com/may2014/illusions**.)

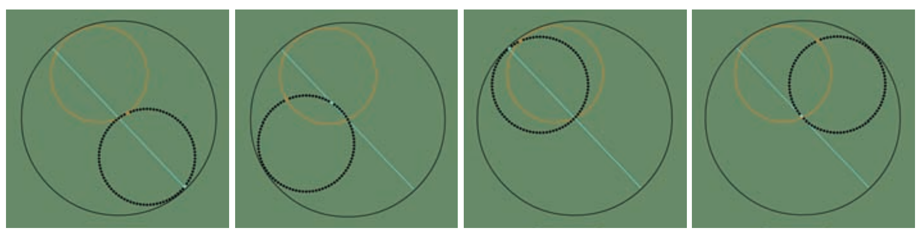
TRANSLATION WITH A TWIST



A famous proof by Swiss mathematician Leonhard Euler indicates that if you move a rigid body so that only a single point on that body remains fixed, you will have achieved rotation. As mathematicians of the mind, Ono and his colleagues Akiyasu Tomoeda and Kokichi Sugihara did not need Euler's theorem to create the *illusion* of rotation.

Ono, Tomoeda and Sugihara showed that moving certain static figures across a grid pattern causes us to perceive rotation where none exists. Two identical stationary pinwheels seem to spin in *opposite directions* when a grid moves across them. This illusion tells us that the motion we perceive emerges from the interaction between an object's actual motion and contextual information in its background and foreground. Given that everyday objects almost never move in front of an undifferentiated background, you might not be seeing real-world motion as correctly as you think.

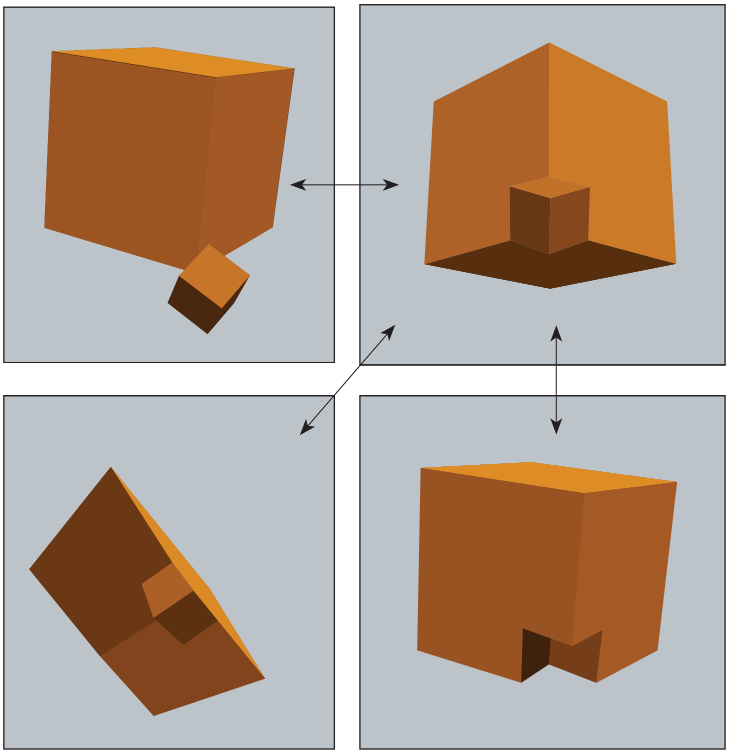
TUSI OR NOT TUSI? THAT IS THE QUESTION ...



Nasir al-Din Tusi, the 13th-century Persian astronomer, mathematically proved that the circular motion of objects, such as gears, could lead to movement in a straight line. Vision scientist Arthur Shapiro of American University and his student Alex Rose-Henig showed why we sometimes perceive straight-line motion from rotation. In their illusion, which won second prize, they use the fact that we group individual moving objects into global structures depending on the statistical relation among those objects. For instance, a set of elements that moves along a straight line or in a circle can look as if it moves in either circular or linear fashion, depending on the phase of the elements—that is, the relative time at which each begins and ends its path. The perception of linear or circular motion can also depend on what you pay attention to, and the effect can be similarly counterintuitive. The illustration above depicts a black circle in various locations as it circumnavigates the interior of a larger one. The blue dot, which sits on the smaller circle, traverses a linear path (*blue line*) as the circle moves. If you focus on that spot, however, the black circle appears to spin. The orange dot on the same circle takes a circular route (*orange path*). But if you zoom in on it, the circle's motion will look linear.

FAST FACTS
ILLUSION OF REALITY

1. You have never lived in reality. Instead your brain gathers bits and pieces of data from your sensory systems and builds a virtual simulation of the world.
2. One groundbreaking new illusion exploits the fact that our perception of motion emerges from the interaction between an object's actual motion and its background.
3. The Best Illusion of the Year Contest brings scientific and popular attention to perceptual oddities. Anyone can submit an illusion to next year's contest at **http://illusionoftheyear.com/submission-instructions for the rules**



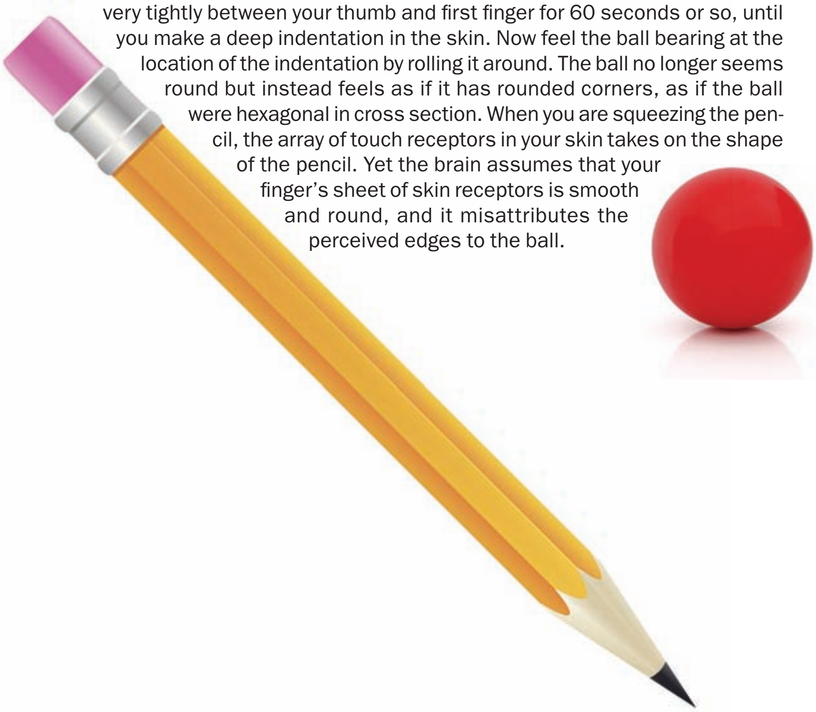
TRIPLE VISION

We have all seen ambiguous figures in which the same object can be seen in two different ways. One example is the venerable Necker cube. Neuroscientists use such visual stimuli in experiments to help find the circuits in the brain responsible for conscious perception. They reason that our shifting perspective on ambiguous figures is based on changes in neural activity that do not correspond to alterations in the physical image cast on your retina. Thus, a modulation of the neural response under these conditions may underlie perception that is divorced from reality.

Vision scientists Guy Wallis and David Lloyd of the University of Queensland in Australia noticed that some ambiguous figures could be seen three ways, as demonstrated in their uncanny threefold cubes illusion. In this case, the illusionists made a computer model of three different objects that all looked exactly the same when seen from one critical perspective (*upper right image*). From that view, each figure is ambiguous. The brain cannot decide whether the edges are pointing toward or away from the viewer because both interpretations are equally correct. As a result, the brain cycles between the interpretations. The object could be two cubes (*upper left image*), a single cube with a cube-shaped bite out of it (*lower right image*), or a concave surface illuminated from below (*lower left image*). The illusionists then rotated each object to show that when viewed from other perspectives, the figures are clearly distinct. Each one of them represents one of the three possible visual interpretations of the item from the ambiguous perspective.

THE CASE OF PETER AND SOME KNOBBY BALLS

Illusions are not just for the visual system. They also happen in the sense of touch, as noticed by cognitive neuroscientist Peter Tse of Dartmouth College. Squeezing a ball after pinching his pencil, Tse felt that something was amiss. Try it yourself at home. Get a pencil and a small, round hard sphere, such as a ball bearing or a marble. First, squeeze the pencil lengthwise very tightly between your thumb and first finger for 60 seconds or so, until you make a deep indentation in the skin. Now feel the ball bearing at the location of the indentation by rolling it around. The ball no longer seems round but instead feels as if it has rounded corners, as if the ball were hexagonal in cross section. When you are squeezing the pencil, the array of touch receptors in your skin takes on the shape of the pencil. Yet the brain assumes that your finger's sheet of skin receptors is smooth and round, and it misattributes the perceived edges to the ball.



NO SMOKE OR MIRRORS

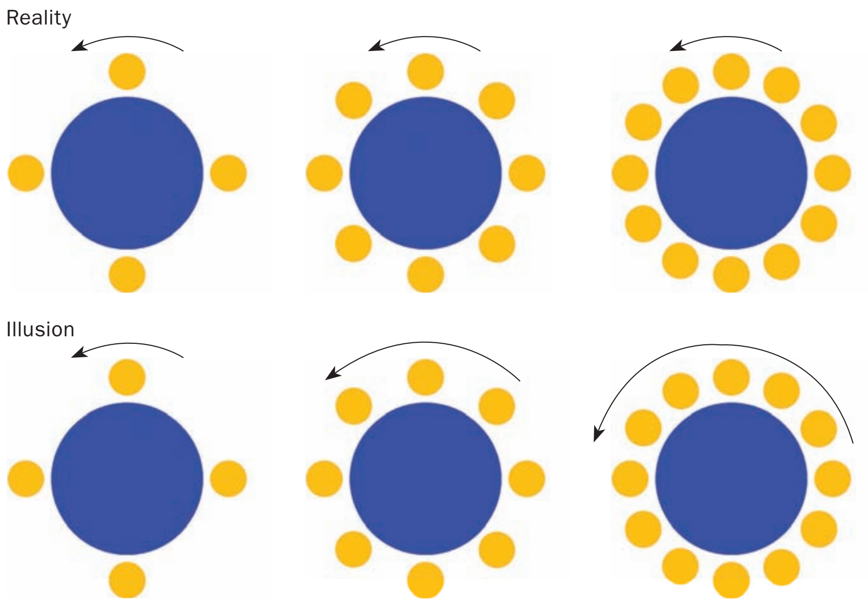
Clinical psychologists Sidney Pratt, Martha Sanchez and Karla Rovira of Sin Humo (a treatment program meaning "without smoke") in Costa Rica described an unusual top-10 illusion at the contest gala: they made pleasure disappear by blocking vision. Their idea came about after finding that a relaxation technique that involved closing the eyes while smoking could decrease the enjoyment people felt from a cigarette. Less enjoyment, they reasoned, would lead to weaker addiction. Pratt's team then wondered whether the patients' reduced gratification resulted primarily from the closing of the eyes—which prevented them from seeing the burning cigarette—rather than from relaxation per se.

To test this idea, they simply blindfolded patients while they smoked—and found that this manipulation accounted for the reduced pleasure of smoking. The contest judges classified this demonstration as an illusion because the smokers' perceptions did not match the biochemical reality of smoking, in which the amount of pleasure from a cigarette should be based on the amount of nicotine delivered. That amount, however, is the same with and without the blindfold.

In light of this effect, the researchers reasoned that seeing the smoke from a cigarette, along with its presumed association with smoking satisfaction in the past, might bolster nicotine addiction among smokers. The blindfolding technique is now the cornerstone of the team's antismoking treatment plan.

GUY WALLIS AND DAVID LLOYD (*top*); THINKSTOCK (*pencil*); ISTOCKPHOTO (*blindfold and ball*)

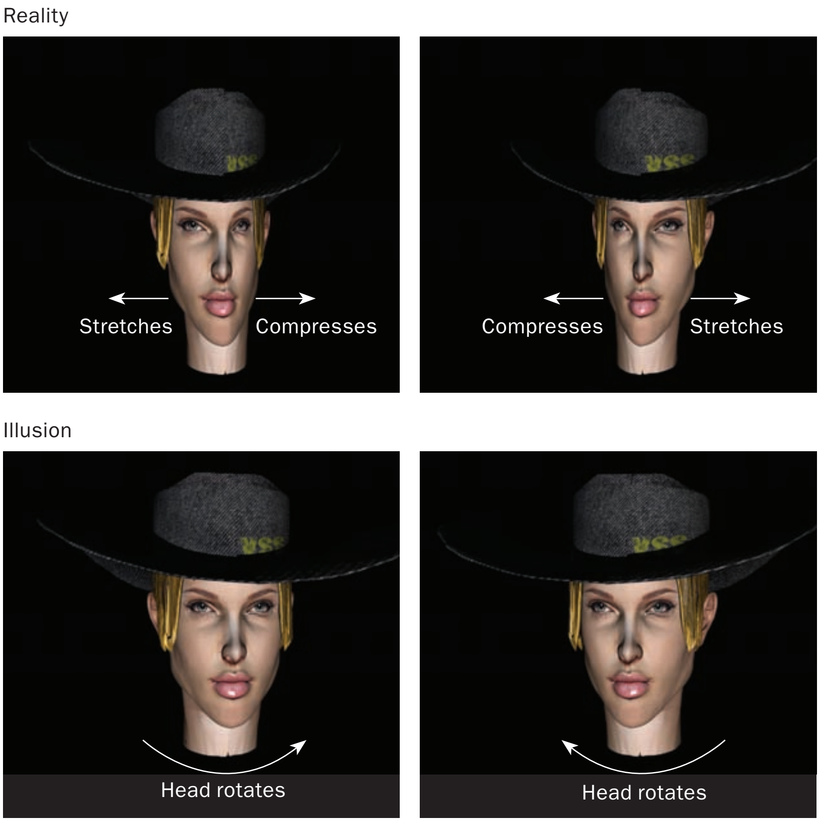
MORE LEGS MOVE FASTER?



While working on a motion perception project, Alan Ho of Ambrose University College in Calgary noticed that a computer representation of a turning fan blade appeared to spin twice as fast after he doubled its number of blades. To achieve the same effect, cartoon animators draw multiple legs and feet on fast-moving characters such as Wile E. Coyote. In their coyote illusion, Ho and Stuart Anstis of the University of California, San Diego, demonstrated this principle more generally by showing that increasing the number of circles orbiting a larger circle creates the perception of faster motion even when the circles' speed remains constant.

The visual system can track only the movement of slow, widely spaced spots. As the spots speed up or come closer together, they tend to blur or fuse perceptually. In such cases, Ho and Anstis showed, the brain uses a different strategy to compute velocity. Instead of tracking each moving element, the brain calculates the change of the stimulus over time at each position around the loop. That is, it simply counts the number of flickers it detects at each point in space. As a result, doubling the number of fast-moving elements means the brain sees twice as many flickers and concludes that the speed has doubled.

This illusion has commercial and practical applications. Programmers could use it to create the perception of rapid action in computer games, and advertisers might add flashing lights to billboards when they wanted viewers to perceive faster motion. Their discovery also has implications for road safety. When you are driving on a highway, roadside trees, fence poles and guardrails that are planted close together may lead you to think you are moving faster than you are.



STRETCHING THE TRUTH

Rigid objects—or those that we *expect* to be rigid—appear to rotate when they are stretched asymmetrically. In a dramatic example, created by psychologists Attila Farkas and Alen Hajnal of the University of Southern Mississippi, a stationary computer-generated head appeared to turn when its two halves were simply stretched—but not actually rotated.

ALAN HO AND STUART ANSTIS *(top)*; ATTILA FARKAS AND ALEN HAJNAL *(bottom)*

FURTHER READING

- Find all the winners of the Best Illusion of the Year Contest: **http://illusionoftheyear.com**
- Alan Ho talks about his speed illusion: **https://ambrose.edu/news_and_events/dr-alan-ho-finalist-best-illusion-year-competition**

From Our Archives

- **169 Best Illusions.** Scientific American Mind Special Issue; Summer 2010.
- **10 Top Illusions.** Susana Martinez-Conde and Stephen L. Macknik; May/June 2011.
- **187 Illusions: How They Twist Your Brain.** Scientific American Special Collector's Edition; September 2013.