MIRAGES AND MIND BENDERS

THE 10 BEST ILLUSIONS OF THE YEAR

By Susana Martinez-Conde and Stephen L. Macknik

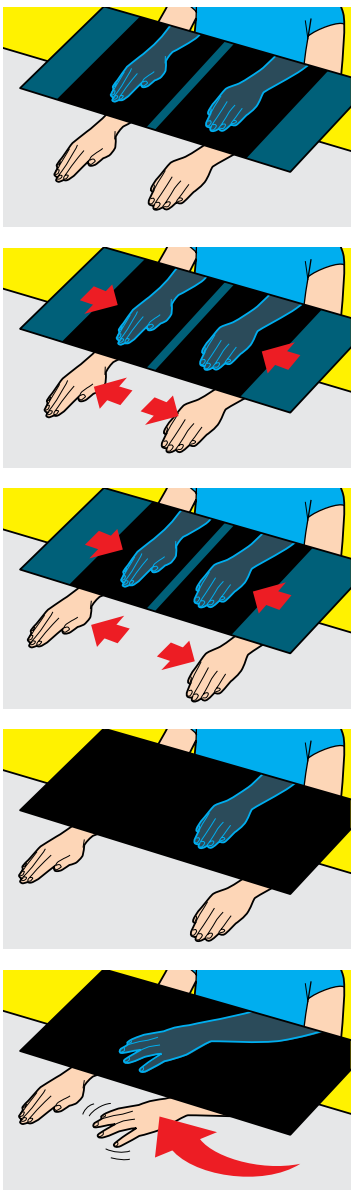
A trusting young woman puts her hands in a box with a transparent top. She is participating in an experiment, but this one has the aura of a magic show. The investigators ask her to hold her hands steady between vertical blue lines. She does so, watching her hands carefully. They do not appear to move, nor does she feel as if they are moving.

The investigators flick a switch, and the box darkens on one side, obscuring her right hand. They ask her to reach across with her left hand to touch her now invisible right. She complies, but her eyes suddenly widen with alarm. All she feels with her left hand is empty space.

"Where's my hand gone?" she asks with growing anxiety, then suddenly she explodes with laughter as she realizes that these scientists are of the mad variety. Still, just to be sure, she pulls both her hands from the box to check that they are still there. They are. This time.

This scene, captured on video, helped the inventors of the mirage multisensory illusion box win first prize at the 2012 Best Illusion of the Year Contest. As with many well-known illusions, this one came about by accident. Three psychologists at the University of Nottingham in England created the box to study how the brain integrates visual input, bodily sensations and tactile information. One day one of them, Roger Newport, was trying to fix a misalignment in the box. He discovered "that my right hand was in the wrong place and my left was out of sight. I tried to touch my left hand with my right and missed it. I was so surprised I decided to see whether I could re-create the feeling experimentally."

Equipped with a camera, a mirror and a monitor, the box created the illusion that the woman was looking at her own hands when in fact she was seeing a video re-creation of them. The hand images, manipulated by computer software, moved slowly inward. To compensate, the woman moved her hands outward—although it all happened so gradually that she did not notice. In less than a minute, the space between



Illustrations by Jason Lee

her hands became much greater than she realized.

The disappearing hand trick was one of 59 illusions submitted to the contest this year by psychologists, neuroscientists, artists, mathematicians and tinkerers from around the world. A panel of six judges winnowed the entries to a top-10 short list, and last May in Naples, Fla., an audience of 1,000 illusion lovers selected three winners.

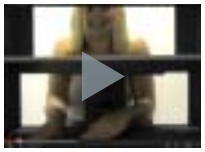
The contest, which began in 2005, honors the best new illusions created or published within the preceding year, from all sensory modalities. It is hosted by the Neural Correlate Society, a nonprofit organization that brings together researchers from fields as diverse as art, mathematics, psychology and neuroscience to promote scientific understanding of perception and cognition. One of us (Martinez-Conde) is president of the society and the other (Macknik) vice president, and we both help orchestrate the event. *Scientific American* is a longtime sponsor.

The contest is playful, but for scientists it serves a deeper purpose. By definition, we experience illusions when the physical reality of the world fails to match our perception. All these little hiccups are an opportunity to peer behind the curtain, to learn more about how the brain works.

NOW, WHERE DID I PUT MY HAND?

In everyday experience, sensations such as sight, touch and proprioception (the awareness of one's body in space) work together to inform us about the location of our various body parts. Separate these inputs, as the creators of the mirage illusion box did, and the brain is easily confused. The woman in these images is surprised after trying to touch her hand and discovering that it is not where she thought it was.

To understand this illusion, think of how jerky a baby's early movements are and how unsteady she is as she learns to walk. She dynamically adjusts and readjusts virtually every muscle in her body as she struggles to remain upright. You do the same, even when sitting still, just more smoothly and without conscious oversight. The mirage box, created by University of Nottingham psychologists Roger Newport, Helen R. Gilpin and Catherine Preston, reveals what happens when these bodily sensations are dissociated from visual input.



For a demonstration, visit http://illusionoftheyear.com/2012/the-disappearing-hand-trick/, and for an amusing collage of reactions from study participants, see www.youtube.com watch?v=-4r1ANw0X3I

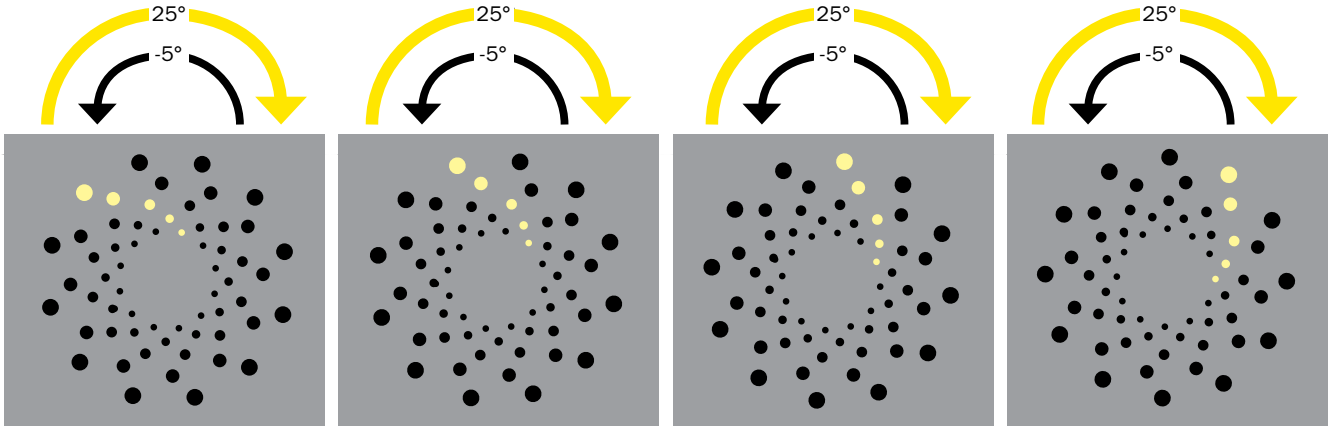
COURTESY OF ROGER NEWPORT, HELEN R. GILPIN AND CATHERINE PRESTON *University of Nottingham (screenshot)*

COLOR WAGON WHEEL

Vision scientist Arthur Shapiro, an illusion contest veteran with four previous trophies, bagged third prize in collaboration with his colleagues William Kistler and Alex Rose-Henig of American University. The team was inspired by a classic phenomenon known as the wagon wheel illusion.

In the standard wagon wheel, nested circular rows of black disks rotate clockwise but appear to rotate counterclockwise. The effect relies on the specific geometry. The disks in each row are spaced 30 degrees apart, and when they jump clockwise by intervals of 25 degrees, you have the option to interpret the jump as either a large clockwise turn of 25 degrees or a small counterclockwise turn of five degrees. Your brain chooses the less dramatic movement as the most probable one, and so the wheel appears to turn counterclockwise.

Shapiro and his colleagues had the idea to color some of the disks yellow. The result is a novel and striking illusion: a wheel that spins simultaneously in both directions (http://illusionoftheyear.com/2012/color-wagon-wheel). When you look at the yellow disks, you can tell that they are moving clockwise because their 25-degree jump is unambiguous—there are no other nearby yellow disks to confuse the matter. Yet you still have a strong sensation that the wheel, as a whole, moves in the opposite direction because the remaining black disks continue to drive the wagon wheel illusion.



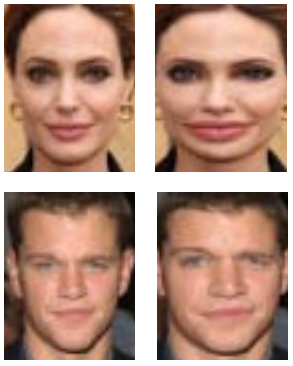
FAST FACTS

Gray Matters

1» The brain evolved not to interpret reality perfectly but to make quick and useful judgments about our surroundings. Illusions reveal some of these quirky neural shortcuts.

2» One groundbreaking new illusion exploits the fact that a shift in attention (with no change of gaze) changes what we see. Two others trade on the characteristics of peripheral vision, which registers motion but misses key details such as an object's true position.

3» The Best Illusion of the Year contest brings scientific and popular attention to these delightful perceptual oddities. Anyone can submit an illusion to next year's contest: see http://illusionoftheyear.com/submission-instructions for the rules.



WHEN CELEBRITIES TURN UGLY

The prize for second place also resulted from a chance discovery. An undergraduate working with cognitive scientist Matthew Thompson of the University of Queensland in Australia was up late, preparing a set of photographs for an experiment on face perception. The student, Sean Murphy, aligned the faces at the eyes and skimmed through them in his computer. After a few seconds, he began to see highly deformed and grotesque faces staring back at him (our interpretation is the retouched photographs at the right). Surprised, he looked one by one at the faces that had struck him as the ugliest. "Each of them appeared normal or even attractive," Thompson says. "Sean had discovered the flashed-face distortion effect." The illusion works because our visual system processes each face not as an isolated entity but in comparison with the faces that precede and follow it, Thompson says. "Aligning the faces and presenting them quickly makes it easy for us to compare them, so their differences get more extreme," he adds. You may be thinking, okay, the illusion may work with the faces of most of us mere mortals, but surely the scientists couldn't make Brangelina look hideous, right?

Check out the two videos at http://illusionoftheyear.com/2012/when-pretty-girls-turn-ugly-the-flashed-face-distortion-effect

COURTESY OF ARTHUR SHAPIRO, WILLIAM KISTLER AND ALEX ROSE-HENIG *American University (top)*; S. BUKLEY *Shutterstock (Angelina Jolie)*; SHUTTERSTOCK *(Matt Damon)*; COURTESY OF JASON TANGEN, SEAN MURPHY AND MATTHEW THOMPSON *University of Queensland (screenshot)*

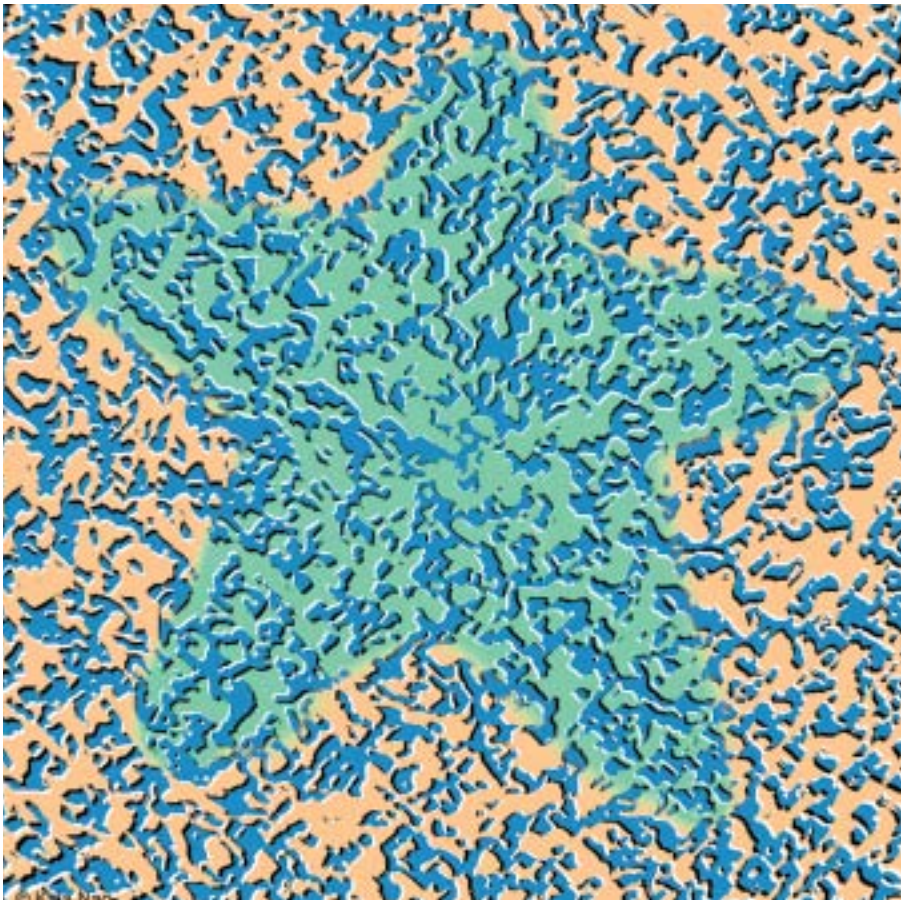
FLOATING STAR

This five-pointed star is static, yet observers experience the powerful illusion that it is rotating clockwise. Created by artist Joseph Hautman, who moonlights as a graphic designer under the pseudonym "Kaia Nao," it is a variation on the famous rotating snakes illusion created by vision scientist Akiyoshi Kitaoka of Ritsumeikan University in Kyoto.

Hautman determined that an irregular pattern, unlike the geometric one Kitaoka used, was particularly effective. Recent research we have done with our Barrow Neurological Institute colleague Jorge Otero-Millan reveals that among the key elements that make this type of illusion work are the small, jerky eye motions that people unconsciously make when looking at an image (known as microsaccades).

In Hautman's illusion, each of the blue jigsaw pieces has a white or black border against a lightly colored background. As you look around the image, your eye movements stimulate motion-sensitive neurons. These neurons perceive direction by virtue of the shifting lightness and darkness boundaries that indicate an object's contour as it moves through space. In the floating star image, carefully arranged transitions between white, light-colored, black and dark-colored borders fool the neurons into responding as if they were seeing continual motion in the same direction, rather than stationary edges.

Hautman next intends to find out if his technique can "animate" static images of flowing fluids or weather patterns.



SWELLED HEADS

Turns out that compliments don't make people's heads expand; chipmunk cheeks do. Cognitive scientists Kazunori Morikawa and Eri Ishii of Osaka University recently discovered a phenomenon they call the head size illusion. The two faces shown here are identical except that in one image the man has a wider jaw and fuller face. The fatter head appears larger, but it is not.

The head size illusion demonstrates that the brain does not determine the size of visual stimuli in isolation; it compares objects and features with those nearby in the visual scene. The illusion occurs in everyday life, Morikawa says, and offers an opportunity. "If one part of your face or body appears wider or thinner than average, other parts appear wider or thinner, too. You can take advantage of such illusions to make yourself look better, using effective makeup and clothing," he explains.

(The Authors)

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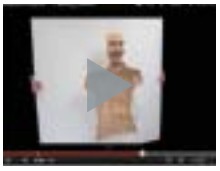
COURTESY OF KAIA NAO (*top*); COURTESY OF KAZUNORI MORIKAWA AND ERI ISHII *Osaka University* (*bottom*)

BEND IT LIKE LINDA BLAIR

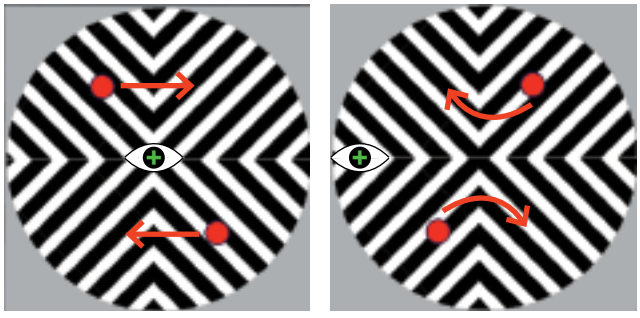
During the 1974 screening of the classic horror flick *The Exorcist,* starring Linda Blair as a demon-possessed girl, a spectator fainted in shock and broke his jaw on the seat in front of him. He sued Warner Brothers and settled out of court for an undisclosed sum. The exorcist illusion, presented by vision scientist Thomas Papathomas of Rutgers University, also made jaws drop, though with less severe consequences.

Papathomas produced this three-dimensional illusion with the help of three Rutgers colleagues: technician Tom Grace, Sr., artist Robert Bunkin and computer graphics expert Marcel de Heer. The team had earlier created hollow face illusions (where the inside of a hollow mask is cleverly painted to make it appear to protrude). Now they have created a "hollow body" illusion, with a critical twist: they paired a hollow mask with a nonhollow torso, and vice versa. The sculptures have no moving parts, but when the head-torso composites are rotated, "the effect is a flexible, twisting neck out of a 3-D rigid [body], like in *The Exorcist,*" Papathomas says.

This illusion reveals some of the biases the brain uses to interpret the orientation of faces and bodies. For example, your brain assumes that people's faces and bodies are lit from above—namely, by the sun. So when you view a hollow mask or body and the lighting orientation appears reversed, so does the rotational direction.



Visit http://illusionoftheyear.com/2012/exorcist-illusion-twisting-necks to watch the head of the devil's spawn head do an illusory 360 around its torso.

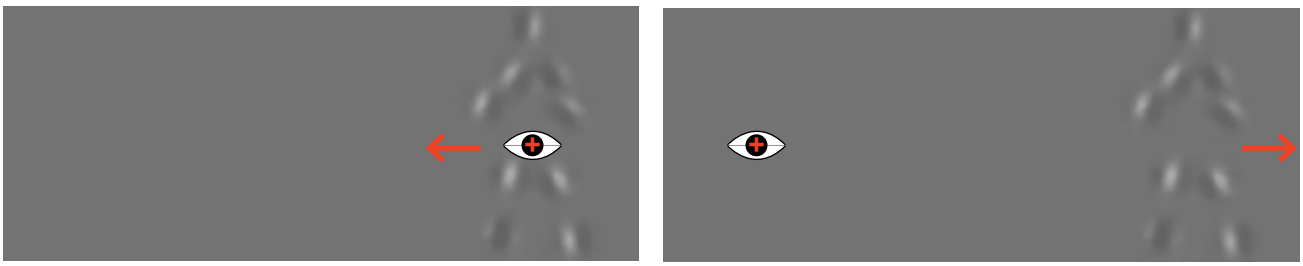


QUIRKS OF PERIPHERAL VISION, PART 1

A colored dot moves horizontally over a patterned black-and-white background. When you look straight at it, you see it accurately. But if you glance at it from the corner of your eye, the dot suddenly appears to glide diagonally. This animated illusion by vision scientist Stuart Anstis of the University of California, San Diego, demonstrates the different roles of central and peripheral vision. "In central vision, we see the positions of objects very precisely, whether they are stationary or moving," Anstis says. "Peripheral vision is very good at picking up movement. That's why we wave to attract a friend's attention in a crowded airport." But the outskirts of our gaze are not well suited to detecting positions. In this illusion, position and motion distort each other.

Anstis's striking creation has implications for everyday life. "When we drive, our wide-angle vision detects targets lying way out in our periphery. It's important to turn our gaze toward moving peripheral targets, to avoid the weird perceptual distortions demonstrated in my illusion."

See two versions of it at http://illusionoftheyear.com/2012/the-colored-dot-peripheral-vs-central-vision

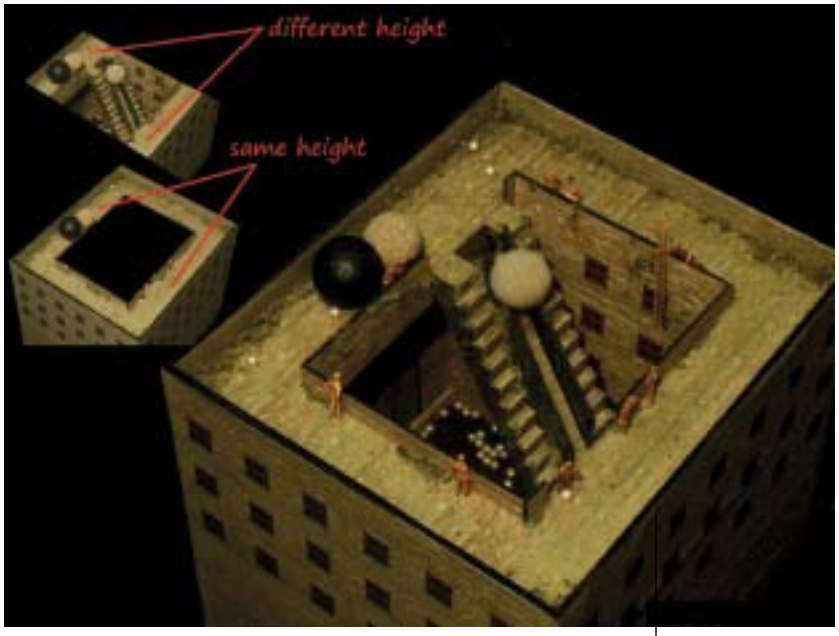


QUIRKS OF PERIPHERAL VISION, PART 2

Vision scientists Steven Thurman and Hongjing Lu of U.C.L.A. created a human figure out of disks known as Gabor patches, which are striped circular or oval patterns with blurry edges. The figure appears to walk to the left when you view it directly. But wait! If you look away the figure suddenly seems to change direction and walk to the right. The direction reversal is created by a disconnect. Thurman and Lu positioned the disks to represent a person walking to the right, despite the overall leftward shift created by the motion within the disks. Our central vision does not pick up the subtle rightward-moving walking cues, but super-motion-sensitive peripheral vision grasps them at once and integrates them into our perception of the object's trajectory.

Take a gander at the ambiguous walker at http://illusionoftheyear.com/2012/peripheral-action-phantom-illusion and go to http://illusionoftheyear.com/finalists_2012/thurman/dancing.mov to see it dancing out of the corner of your eye.

COURTESY OF THOMAS PAPATHOMAS, TOM GRACE SR., MARCEL DE HEER AND ROBERT BUNKIN *Rutgers University (top);* COURTESY OF STUART ANSTIS *University of California, San Diego (middle);* COURTESY OF STEVEN THURMAN AND HONGJING LU *U.C.L.A. (bottom)*

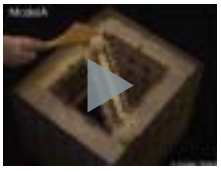


CHANNELING ESCHER

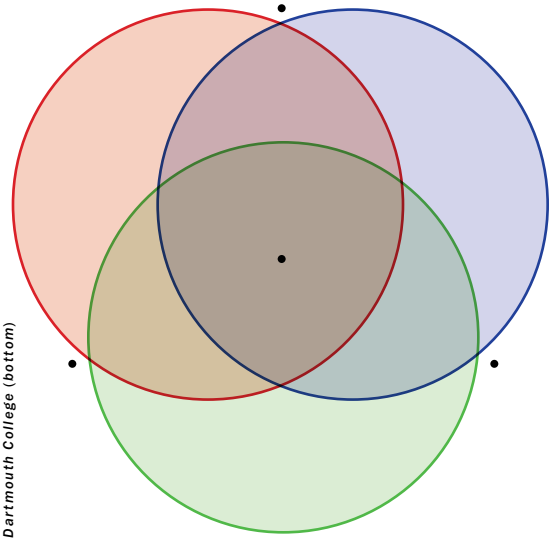
M. C. Escher, the iconic Dutch graphic artist, created etchings of water rolling uphill from his remarkable intuition that human perception assembles the whole of an image out of a multitude of little parts. Neuroscience research has proved Escher right: we now know that the visual system puts together the global perception of a scene from many local relations among object features. As a result, tiny mistakes that are too small to detect locally (and that occur in the real world rarely, if ever) can add up across space to become major mistakes at the global level, and voilà!—you have an impossible image.

Artist Sachiko Tsuruno of Kinki University in Japan has taken that concept to the next level. She built an architectural model that resembles the interior of a fortress and filmed balls rolling along inclines inside it. But because of the perspective she shot it from, you cannot shake the perception that the balls are rolling uphill between two level surfaces, as ridiculous and impossible as that may seem to your rational mind.

The clues to her deception are all there, but because they are virtually invisible at the local level the image is devastatingly convincing at the global level. Balls never do roll uphill unaided, so it must be that the uphill roll is actually downhill. The only possibility, then, is that the construct is not a tower at all but a clever representation of surfaces that look like a tower when seen from one specific perspective. Among the telltale signs: If you black out the staircase (a local clue), the top of the tower looks flat, whereas if you black out the sides (another local clue), it looks as if the top is on two levels connected by a staircase (*see inset*). The brain is wired to interpret flat surfaces as three-dimensional, she says, adding, "My illusion occurs because most viewers misinterpret the 3-D structures."



Marvel at it at http://illusionoftheyear.com/2012/illusion-of-height-contradiction



FILLING IN THE BLANKS

One new illusion is so significant that we think it should be included in the next generation of cognitive neuroscience textbooks. Vision scientist Peter Tse of Dartmouth College, winner of two previous trophies, grouped three colored disks so that they overlap in the center like a Venn diagram. If you fix your gaze on the central intersection and attend to one disk only, that entire disk will appear to take on the uniform color that it has in its outer region, where it does not overlap with the other disks. The attended disk will also look as if it is floating transparently above the other disks, despite the fact that the colors are mixed in some regions—and that the center is actually gray! No matter which disk you focus on, it will seem to fill in with a single homogeneous color.

The illusion demonstrates the brain's remarkable ability to see different things in the same scene, depending on its focus. For example, when you look at a pond, you may see clouds reflected on the surface, but with a subtle shift of attention you can instead find yourself looking at the stones at the bottom. In the same way, as you shift your attention to a specific disk in Tse's drawing, your brain suppresses the other disks and enhances the one you are looking at.

For an animated version, go to http://illusionoftheyear.com/2012/attentional-modulation-of-perceived-color

(Further Reading)

- **169 Best Illusions.** *Scientific American Mind special issue,* Vol. 20, No. 1; Summer 2010.
- **Multisensory Disintegration and the Disappearing Hand Trick.** Roger Newport and Helen R. Gilpin in *Current Biology,* Vol. 21, No. 19, pages R804–R805; October 11, 2011.
- **Microsaccades and Blinks Trigger Illusory Rotation in the "Rotating Snakes" Illusion.** Jorge Otero-Millan, Stephen L. Macknik and Susana Martinez-Conde in *Journal of Neuroscience,* Vol. 32, No. 17, pages 6043–6051; April 25, 2012.

COURTESY OF SACHIKO TSURUNO *Kinki University (top);*
COURTESY OF PETER U. TSE *Dartmouth College (bottom)*