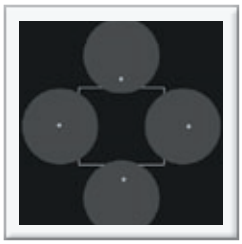
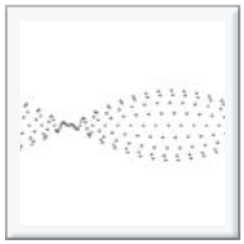




10 TOP ILLUSIONS

Balls that roll uphill, bathtubs that stretch and shrink, freaky faces and throbbing hearts. Welcome to the year's best visual tricks

By Susana Martinez-Conde and Stephen L. Macknik

A Japanese miner climbs onto the stage, his helmet light bobbing and a pickax slung over his shoulder. He swings the pick a few times before kneeling to inspect something unusual and then worries at some loose rubble with his hands. Suddenly his face lights up, and he turns to the audience, his newfound riches held forward in his open hands. "I have discovered a new supermagnet that attracts wood," he announces. Okaaaay....

A video begins playing overhead, and the audience sees four wood balls rolling uphill in open defiance of the laws of gravity. Pulled by a magnet? Not really. The "miner" is mathematical engineer Kokichi Sugihara of the Meiji Institute for Advanced Study of Mathematical Sciences in Kawasaki, Japan, and his magnetlike slopes illusion is the winner of the 2010 Best Illusion of the Year Contest. The trick is exposed when the video shows Sugihara's slopes from a different vantage point: the wood balls are actually rolling down, not up. The slopes are cleverly designed to produce the antigravity illusion when seen from a specific point of view.

Sugihara's invention exemplifies several of the most popular themes in illusions today. It relies not only on a trick of perspective but also on perceptual ambiguity. There is more than one way to perceive the "magnetic" slopes, but our visual system's expectations make us prefer one interpretation—and illusions are a way to fool the brain into revealing those systems. "We are surrounded by many industrial products that are made with right angles, such as desks, boxes and buildings," Sugihara explains. When confronted with an image in which multiple interpretations are possible, we choose the version that allows us to see rectangular solids. In Sugihara's prizewinning illusion, none of the columns that support the ramps are vertical. Yet we interpret them all as perfectly straight.

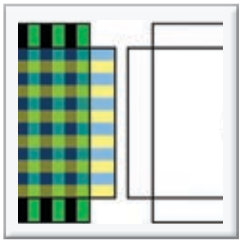
As with many of the newest illusions, Sugihara's impossible-motion demonstration is dynamic: to fully appreciate the magic, you need to see the balls moving. Al-

AND THE WINNER IS ... Mathematical engineer Kokichi Sugihara (*far left*) raises his pickax in victory as the master of ceremonies, vision scientist Stuart Anstis of the University of California, San Diego, announces the winner of the 2010 Best Illusion of the Year Contest. *Scientific American* was the premier sponsor of the contest.

MAKING MAGIC James Randi (*left*)—magician, escape artist and skeptic known as the Amaz!ng Randi—demonstrated magic tricks during the vote counting at the 2010 illusion contest. On hand to help was cognitive psychologist Daniel J. Simons (*right*), author of the monkey business illusion.

KOKICHI SUGIHARA (*magnetlike slopes*); BART ANDERSON (*counterintuitive illusory contours*); JAN KREMLACEK (*two sinusoids: 6–1 perceptions*); LYDIA MANIATIS (*stretching out in tub*); PETER MEILSTRUP AND MICHAEL SHADLEN (*steerable spiral*); ALAN STUBBS (*finalists and Randi/Simons, bottom*)




DANIEL SIMONS (*monkey business*); KOHSKE TAKAHASHI, RYOSUKE NIIMI AND KATSUMI WATANABE (*blurry heart*); PETER THOMPSON (*fat face thin*); PETER TSE (*attention-biased afterimage rivalry*); MAARTEN WIJNTJES AND SYLVIA PONT (*illusory gloss*); KOKICHI SUGIHARA (*magnetlike slopes, bottom*)

though illusionists continue to produce classical illusions using still photographs or even just a few lines on paper, computer and video technologies have made it possible to create increasingly complex moving-picture illusions. Several of the top 10 illusions of 2010 are animations that cannot be shown here, but you can see them in action at http://illusionoftheyear.com.

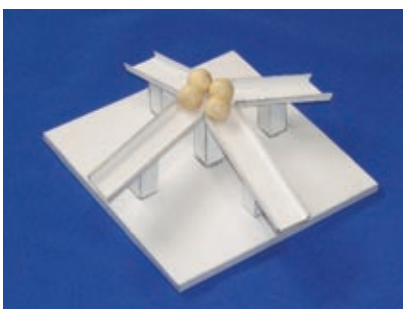
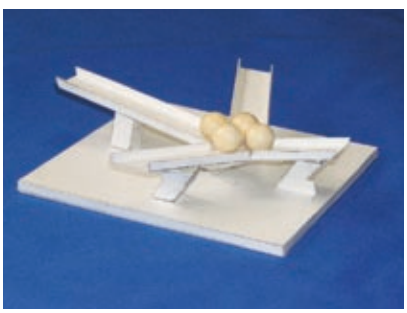
Because illusions enable us to see things that do not match physical reality, they are critically important to understanding the neural mechanisms of perception and cognition. The annual Best Illusion of the Year Contest celebrates the inventiveness of illusion creators around the world: researchers, software engineers, mathematicians, magicians, graphic designers, sculptors and painters fascinated with mapping the boundaries of human perception.

Whereas scientists once created illusions from simple lines and shapes and artists focused on making eye-popping illusions, the overlap between science and art is now greater than ever. Scientists are using graphic-design tools to make their illusions more artistic, and artists have grown more knowledgeable about the neuroscience behind the magic.

Illusions competing in the contest must be novel—that is, previously unpublished or published no earlier than the year preceding the contest. An international panel of experts selects the 10 illusions that are the most counterintuitive, spectacular, beautiful and significant to the understanding of the human mind and brain. The creators are invited to present their awe-inspiring brain twisters at an awards gala where the audience votes to choose the first-, second- and third-place winners: the "Oscars" of illusion.

Anyone can submit an illusion to the contest, which is sponsored by *Scientific American*. Instructions are posted at http://illusionoftheyear.com/submission-instructions. The 2011 event is scheduled for Monday, May 9, at the Philharmonic Center for the Arts in Naples, Fla. Please join us and vote for the best illusion of the year! **M**

SUSANA MARTINEZ-CONDE and STEPHEN L. MACKNIK are laboratory directors at the Barrow Neurological Institute in Phoenix. They are authors of *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions,* with Sandra Blakeslee, and serve on *Scientific American Mind*'s board of advisers.

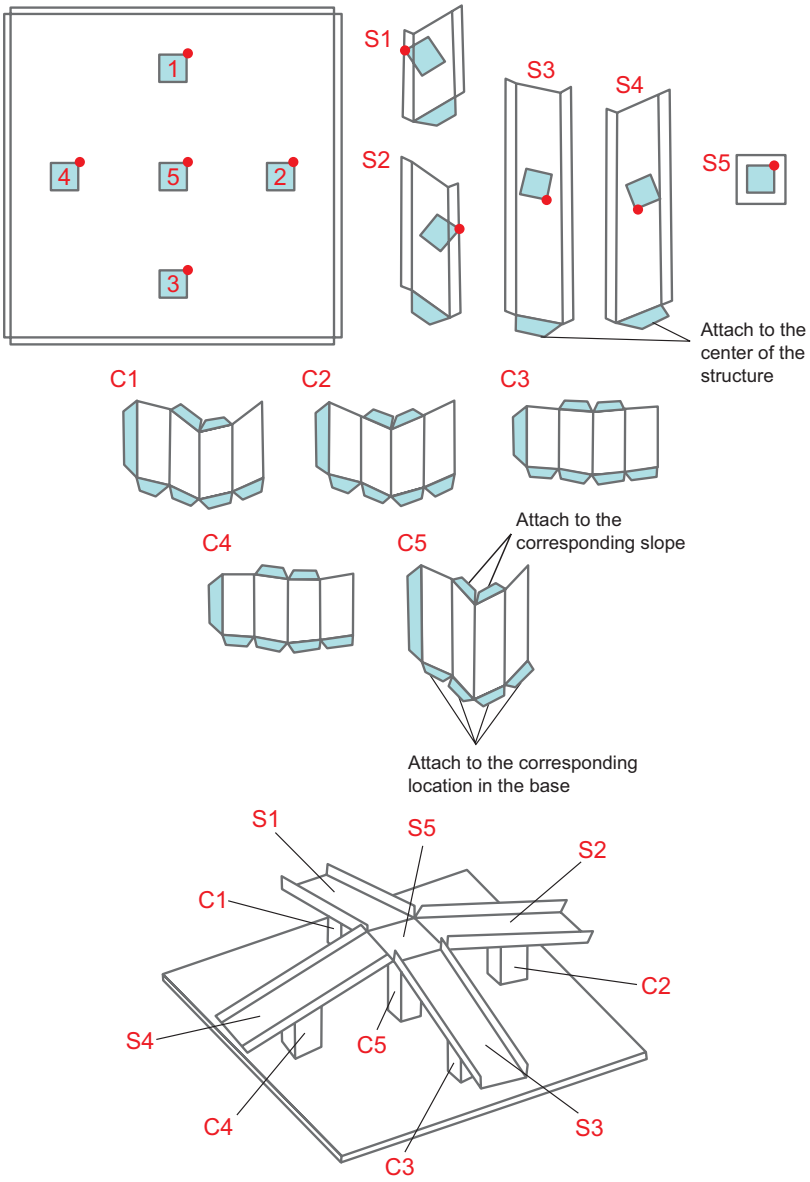




1st Place

Impossible Motion

In the magnetlike slopes illusion, wood balls appear to roll up four ramps in defiance of gravity. In reality, the balls roll down the ramps, but when viewed from a specific vantage point the configuration of the supporting columns makes it look like the center column is the tallest.

Japanese mathematical engineer Kokichi Sugihara discovered the illusion using a computer program designed to read 3-D line drawings. He tested the program by feeding it images of impossible, Escher-esque objects. He expected the program to respond with an error message; instead the software interpreted some of the images as peculiar 3-D solids. Sugihara assumed he had a bug in his code but soon realized that the software was recognizing objects that were only impossible from a certain point of view. Delighted, he set out to construct the actual objects and added motion later to enhance the illusion. You can watch an animation of the illusion at http://illusionoftheyear.com/2010/impossible-motion-magnet-like-slopes.



Make Your Own Magnetlike Slopes

You can make your own gravity-defying slopes at home. Print the patterns on heavy paper or cardstock, cut out the individual parts (base, columns and slopes) and fold them as shown.

Assemble the parts by gluing the slopes to the corresponding columns and then gluing the columns to the base in the positions shown. For example, column C1 should be glued to slope S1 and then mounted on the base at position 1. Glue the columns to the slopes at the angles indicated by the square tab drawn on the rear center of each slope. The glued edge of each column should be positioned at the corner indicated by the red dot on both the corresponding slope and the base. Columns C1 and C2 should extend partly beyond the outside edges of slopes S1 and S2. The columns should lean, and all four slopes should be almost horizontal with a very gentle tilt toward the center (as shown in the photograph on the bottom right of the preceding page, where slope S1 is at the right).

Rotate the structure until you find the viewpoint from which all five columns look parallel (with the corner of the base between columns C3 and C4 closest to you). Then amaze your friends by rolling balls or marbles up the ramp. Hint: The effect is stronger if you close one eye.

➥For more instructions on how to create this illusion yourself, visit **ScientificAmerican.com/mind/may2011/magneticslopes**

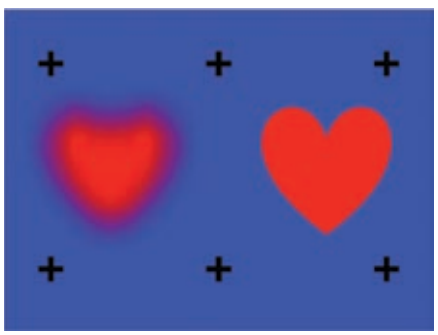
FAST FACTS

Seeing Is Believing

1» **Because illusions trick us into seeing things that do not match physical reality, they give us insights into how our brain works.**

2» **Classical illusions rely on simple lines and shapes, but computer and video technologies are making it possible to create increasingly complex moving-picture illusions.**

3» **The Best Illusion of the Year Contest finds the top 10 illusions created by scientists and artists.**



Be Still My Heart

The blurry heart illusion is simple yet powerful. Shifting your gaze from one cross to the next makes the blurry heart wobble, but the heart with sharp contours remains stationary. The blurred edges appear to move in a direction opposite to your eye movement. Created by vision scientists Kohske Takahashi, Ryosuke Niimi and Katsumi Watanabe of the University of Tokyo, this illusion works because the blurred edges—when viewed with your peripheral vision—activate motion-detecting neurons as you move your eyes around on the page. Placing a red heart on a blue background enhances the effect, for reasons that are still unknown. "The illusion is so simple, and the illusory effect so large and robust, that we were surprised nobody had reported this illusion previously," its creators explain.

ILLUSTRATION BY MELISSA THOMAS; COURTESY OF XOANA G. TRONCOSO AND KOKICHI SUGIHARA (*instructions*); FROM "ILLUSORY MOTION INDUCED BY BLURRED RED-BLUE EDGES," BY K. TAKAHASHI, R. NIIMI AND K. WATANABE, IN *PERCEPTION*, VOL. 39, 2010 (*heart*)

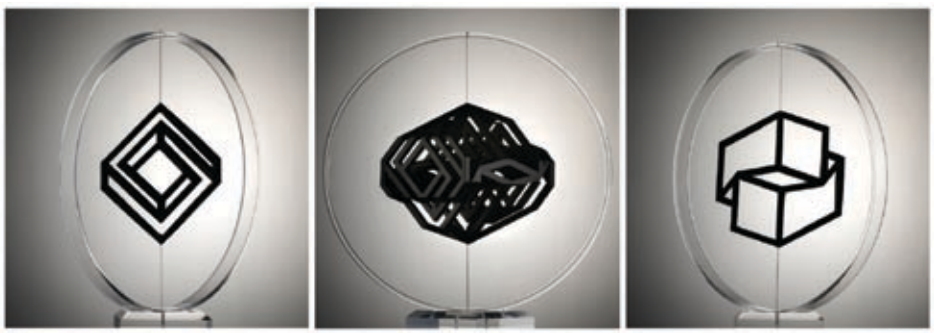
Six in One

The third-place winner in the 2010 illusion contest relies on perceptual ambiguity. "Our brain is able to reconstruct different learned interpretations, but only one can be perceived [at any given moment]," explains Jan Kremlacek of Charles University in Prague, who created the illusion he calls two sinusoids: 6–1 perceptions. Kremlacek combined stationary and moving sinusoids in an animation that can be perceived in any of six different ways: for example, as a rotating double helix, a waving ribbon, or a set of dots bouncing up and down. You can view it at http://illusionoftheyear.com/2010/two-sinusoids-6-1-perceptions.

Kremlacek's illusion is too dynamic to show here, but it harks back to a simple sketch by English artist W. E. Hill entitled *My Wife and My Mother-in-Law,* which was reproduced in the magazine *Puck* in 1915 and described in 1930 by experimental psychologist Edwin Boring of Harvard University. In Boring's words, the drawing (*above, left*) "shows in one figure the left profile of a young woman, three-quarters from behind. The other figure is an old woman, three-quarters from the front. The ear of the 'wife' is the left eye of the 'mother-in-law'; the left eyelash of the former is the right eyelash of the latter; the jaw of the former is the nose of the latter; the neck-ribbon of the former, the mouth of the latter."

Boring's vivid description of the equivocal face launched a thousand experiments in perceptual alternation. Almost 40 years later vision scientist Gerald H. Fischer of Newcastle University in England introduced a third figure, representing a father, to create a triple-ambiguous image (*above, right*).

Pushing the multiambiguity envelope further, Gideon Caplovitz and Peter Tse of Dartmouth College created a four-way illusion in 2006. You can see it at http://illusionoftheyear.com/2006/the-bar-cross-ellipse-illusion. That record stood until Kremlacek created his six-in-one sinusoids.



GUIDO MORETTI (*trophies*); LYDIA MANIATIS (*tubs*)

The "Oscars" of Illusions

The first-, second- and third-place winners of the contest receive trophies designed by Italian sculptor Guido Moretti. Fittingly, the "Guidos" are beautiful illusions themselves. For example, Moretti's ambiguous and impossible trophy shown here can look like three different structures, depending on the viewer's vantage point. "My sculptures are like no other known geometrical solid, but they look just like a cube, a pyramid or another known or absurd solid," Moretti says. "This means that three observers at three different points would see three different solids."

The Long and Short of It

Perceptual ambiguity also lies at the heart of an illusion called stretching out in the tub. From one vantage point, the tub looks long and narrow. But viewed from another angle, it is smaller and squarer.

As with Sugihara's gravity-defying slopes, the tub illusion depends on the viewer's false assumptions about perspective. And like Sugihara, vision researcher Lydia Maniatis of American University in Washington, D.C., discovered the effect serendipitously. Walking down the street one day, she noticed an odd effect as she passed a bathtub company's billboard: as she proceeded from one end of the huge image to the other, the bathtub seemed, impossibly, to stretch and shrink. Intrigued, she walked past the street-level ad again and again, focusing on the dramatic changes in the appearance of the tub.

From one end, the foreshortened tub looked like a large sink. But as Maniatis approached the far end, the tub percept slowly dominated. Her visual system made assumptions about the identity of the object from each angle, giving rise to a different 3-D percept at each location along the image.

For her contest entry, Maniatis re-created the illusion using a different bathtub picture. You can see her entry, along with a video of the billboard that inspired it, at http://illusionoftheyear.com/2010/stretching-out-in-the-tub.

The Invisible Gorilla

In a famous experiment done in 1999, Daniel J. Simons and Christopher F. Chabris, both then at Harvard University, asked subjects to watch two groups of people dribbling and passing a basketball among themselves. Three players wore white shirts; three wore black. The watchers were asked to count the number of passes by the players in white shirts. About halfway through the exercise, a person wearing a gorilla suit walked into the ball-passing scene, beat its chest while facing the camera, then walked out. Simons and Chabris were shocked to discover that 50 percent of the people counting passes failed to notice the gorilla. Their spectacular demonstration became an instant classic, spreading like wildfire to conferences, university courses and textbooks. It is an excellent example of attention bias, a phenomenon in which the brain ignores information that is not relevant to its current task.

The gorilla illusion is so well known that Simons, now at the University of Illinois, decided to create a variation for the 2010 illusion contest. He appeared at the gala dressed as a gorilla, flinging bananas to the audience before he took the stage. "You are all good vision scientists," he said. "You know that when people are passing basketballs, you should be looking for gorillas." The audience roared with laughter at the inside joke. People can only experience the invisible gorilla illusion once. After you know to look for a gorilla, you never miss it again.

Does knowledge of the impending occurrence of unexpected events help you detect other unexpected events? Simons's latest demonstration, called the monkey business illusion, shows the answer to be no. People who know to look for a gorilla are of course more likely to spot the gorilla, but the gorilla is not truly unexpected. These same expert viewers will fail to notice other unexpected events even more than viewers who are unfamiliar with the task.

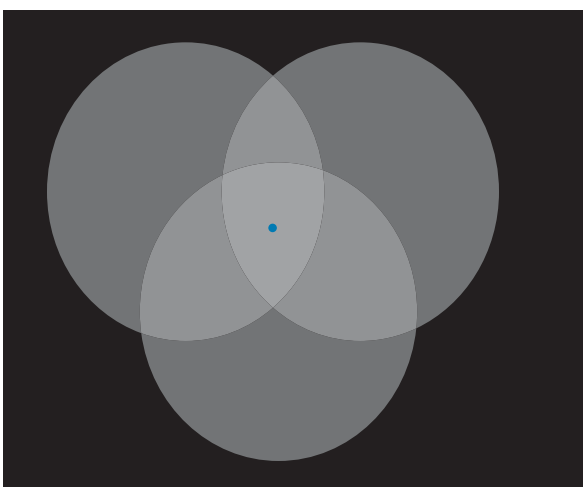
The harder you pay attention during a task, the more powerfully your visual system suppresses distracting information, as we have shown in experiments conducted with neuroscientist Jose-Manuel Alonso and his colleagues at the State

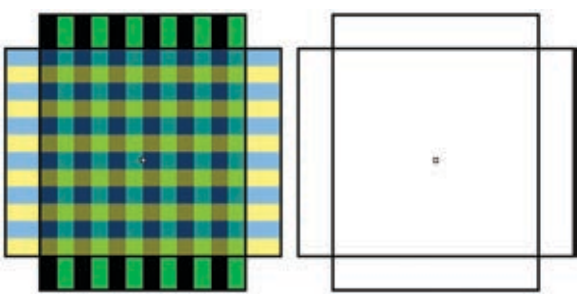
Attention to Afterimages

At the 2005 illusion contest Tse presented one of the simplest but most important illusions ever discovered: three semitransparent overlapping circles (*at right*). Look carefully at the blue dot at the center of the three intersecting disks while directing your attention to each of the three disks in turn. If you are paying attention to the bottom disk, for example, you will see that it looks brighter than the other two disks. The same is true when you turn your attention to one of the other disks. Before Tse's discovery of this illusion, neurophysiologists believed that people cast a spotlight of attention on a specific location, leaving the rest of the world in relative darkness. Tse showed that the spotlight concept was literally true, not just a useful metaphor.

Now, five years later, Tse has shown that attention bias can also affect the perception of afterimages, the illusory images that linger after you look at a bright light or stare at a picture for a while. Focus your gaze on the center of the checkered pattern (*below, left*) for one full minute, then shift your eyes to the empty rectangles at the right. You will see a colorful afterimage filling in the formerly empty frames. Pay attention to the vertical rectangle, and you will see an afterimage that matches it. Pay attention to the horizontal rectangle, and you will see a different afterimage. You can go back and forth between the two afterimages simply by shifting your attention from one rectangle to the other.

Afterimages help scientists understand how neurons in our eyes and brains temporarily cease responding to an unchanging stimulus. It is during this temporary period before the neurons reset to their normal, responsive state that we can see afterimages. Neuroscientists know that retinal neurons play a role in the perception of afterimages, but it has been difficult to demonstrate the importance of neural processing at higher levels in the visual pathway from the eye to the brain. Tse's new illusion unequivocally proves that afterimages can be strongly modulated by cognitive processes such as attention.





University of New York, College of Optometry. The more you watch out for the gorilla that you expect to appear, the more you will miss other changes that are unexpected. Spoiler alert: if you want to see the illusion before we reveal those unexpected changes, go now to http://illusionoftheyear.com/2010/the-monkey-business-illusion.

As the gorilla-clad Simons explained, there are several changes that most people overlook when they watch the monkey business illusion: the background of the image changes color from red to gold, and one of the three black-shirted players leaves the game in midplay by discreetly backing out of the scene.

Simons had one final surprise: "Did any of you spot a pirate?" Simons asked the audience. The spectators groaned, rolled their eyes and shook their heads at yet another impossible oversight. But the undetected pirate was not in the video. Simons pointed to stage right, where a spotlight now beamed on a pirate, previously unnoticed yet completely out in the open for all to see, who was holding a sword to the neck of one of us (Macknik, in his role as the contest's technical director).

Still frames from the illusion show (*a*) the scene before the gorilla appears, (*b*) the gorilla entering and one of the players in black backing out of the scene, (*c*) the gorilla thumping its chest, (*d*) the gorilla exiting, and (*e*) the scene after the gorilla has left. The color of the curtain has changed, and now only two black-shirted players remain.

Face or Vase?

Magician Victoria Skye created this version of the classic face-vase illusion using Randi's portrait. Skye's illusion served as the backdrop for the Amaz!ng Randi's performance.

Face the Facts

Peter Thompson of the University of York in England revolutionized the field of face perception when he created the Margaret Thatcher illusion (*above*) in 1980. The top and bottom rows of Thatcher images are identical to each other but flipped vertically. The top row looks like two upside-down Thatchers, no problem there. But the bottom row looks like a Thatcher on the left and a horrible mutant on the right. The reason is that whereas the left column depicts normal faces (although the upper face is upside down), the right column shows Frankenstein-ish composites of Thatcher with eyes and mouths flipped vertically. The Thatcher at the upper right

does not freak you out, because the eyes and mouth are right side up (although the overall face is upside down), and your face-perception neurons therefore see them as "normal" (even though they do not match the rest of the face). The bottom right image, on the contrary, is creepy because the eyes and mouth are upside down and thus all wrong, despite the fact that the face as a whole is right side up.

Thompson's latest puzzle, the fat face thin illusion (*above*), was one of the 2010 contest finalists. Whereas the Margaret Thatcher illusion showed that faces are more difficult to recognize upside down and that sometimes we misperceive the facial expressions of inverted faces, the new illusion demonstrates that the internal features of a face—such as the eyes, nose and mouth—can distort our perception of face shape: when the face is upside down, it appears to be slimmer.

(Further Reading)

- **105 Mind-Bending Illusions.** *Scientific American Reports* special issue, Vol. 18, No. 2; Summer 2008.
- **169 Best Illusions.** *Scientific American Mind* special issue, Vol. 20, No. 1; Summer 2010.
- **The Invisible Gorilla: And Other Ways Our Intuitions Deceive Us.** Christopher Chabris and Daniel Simons. Crown Archetype, 2010.
- **Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions.** Stephen L. Macknik and Susana Martinez-Conde, with Sandra Blakeslee. Henry Holt, 2010.

PETER THOMPSON; FROM *PERCEPTION*, VOL. 9; 1980, PUBLISHED BY PION LIMITED, LONDON (*Thatcher*); DAN KITWOOD *Getty Images* (*fat/thin faces*); VICTORIA SKYE (*face or vase*)