

Through a Glass, Darkly

Most of us really don't understand how mirrors work, which makes for some fun reflective deception

We are surrounded by mirrors all day, every day—when we drive, brush our teeth, check our hair while heading out the door. Yet for all their ubiquity, mirrors remain somewhat mysterious. In folktales and fiction at least, they can be conduits to spiritual, magical or supernatural realms: mirrors can out the soulless vampires in our midst. They can summon the legendary hook-handed murderer known as Candyman. And the Mirror of Erised—of Harry Potter fame—holds the remarkable power to lay bare its viewer's deepest desire.

Our enchantment with mirrors may stem in part from the fact that they often defy expectations. Not only do we find the right-left reversal of reflecting surfaces discomfiting, but many of our hard-won intuitions about how mirrors work are dead wrong. Psychologist Marco Bertamini of the University of



THE FAIREST OF ALL?

Bertamini and his colleagues Richard Latto and Alice Spooner, both then at Liverpool, coined the term “Venus effect” to describe a curious phenomenon that is exemplified by artistic depictions of the Roman goddess of love. Such portrayals were all the rage in the Renaissance. In some paintings, Venus appears with a small mirror—held by Venus herself or someone close to her—which reflects her face.

Asked to describe paintings such as Titian's *Venus with a Mirror* or Diego Velázquez's *Rokeby Venus* (above), most people say the goddess is looking at herself in the mirror. The problem, though, is that the mirror is not placed in Venus's line of sight. According to the laws of optics, if we can see Venus's face in the mirror, then she is watching us, too, rather than admiring her own image. This kind of illusion is not constrained to paintings: it also occurs in photographs and in real life, and television and film productions often take advantage of it.

One reason for the Venus effect is that we are notoriously bad at estimating the view from someone else's vantage point. Researchers have not ascertained whether the Old Masters included the Venus effect in their works unintentionally or as the result of conscious artistic choices. We may never know, but it seems likely that Velázquez—the creator of the intricate game of mirrors that is the painting *Las Meninas*—might have known mirrors well, along with our inability to truly grasp them.

Liverpool in England and his colleagues have identified three false beliefs we typically have about mirrors: First, people usually predict that they will see themselves in a mirror before they arrive in front of it. In other words, they overestimate what is visible in a mirror. This miscalculation is called the “early error.” Second, most people assume that their projection on a mirror (the outline they could trace with a pen on its surface) is the same size as their body. In reality, that projection, as they see it, is

half the physical size of their body. Third, people tend to think that the mirror projection of their own image will shrink with distance, so they will see their full body in a small mirror if they move far enough away from it. But in fact, distance does not affect the size of a body's projection. Moreover, some research indicates that people see objects in a mirror as somehow less real than nonreflected ones. The illusions we present here all take advantage of how little we grasp about the looking glass. **M**



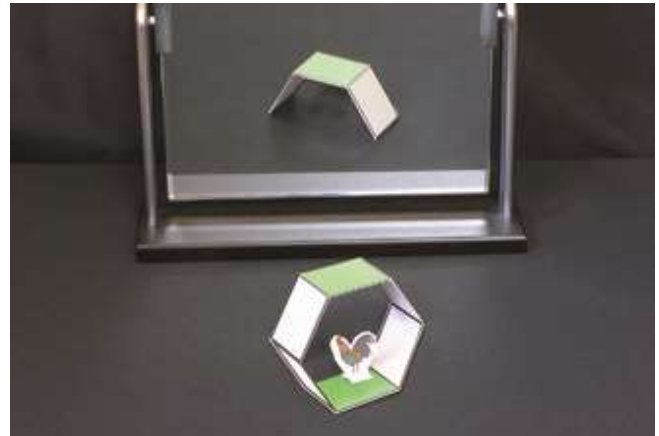
**BY SUSANA MARTINEZ-CONDE
AND STEPHEN L. MACKNIK**



Susana Martinez-Conde and Stephen L. Macknik are professors of ophthalmology at SUNY Downstate Medical Center in Brooklyn, N.Y. They are the authors of *Sleights of Mind*, with Sandra Blakeslee, winner of a Prisma Prize for best science book of the year (<http://sleightsofmind.com>).

VCG WILSON Getty Images (painting); SEAN McCABE (Martinez-Conde and Macknik)

IT'S ALL DONE WITH MIRRORS



Kokichi Sugihara's interest in illusions grew out of what seemed at first like a software mishap. The mathematical engineer at Meiji University in Japan had developed a computer program to read building blueprints and other line drawings of three-dimensional objects. To test it, he fed his program images of impossible objects, such as Penrose steps (famously drawn by M. C. Escher), which look like they go up and down at the same time. To his surprise, the software did not always spit out an error message. Instead it interpreted many of these images as 3-D solids that only appeared impossible if viewed from a specific vantage point. Once he convinced himself that the software's interpretation was correct, he set out to construct "impossible solids," initially with cardboard and more recently with a 3-D printer. In the process, Sugihara also produced new kinds of impossible objects. His most recent illusions rely on mirrors and epitomize the axiom that things are not always as they seem. (For more details and templates to make some of these objects, visit Sugihara's Web site at <http://home.mims.meiji.ac.jp/~sugihara/Welcomee.html>.)

In the illusion on the left, a yellow toy car inside a tiny garage sits in front of a vertical mirror, but the reflection of the garage roof looks to be the wrong shape. Sugihara's trick requires two specific and simultaneous vantage points—seeing the car directly and through the mirror. Yet the actual shape of the roof does not match how it looks from either of these viewpoints. You can construct your own paper model of Sugihara's ambiguous garage roof by following the links at the home page of his Web site.

Sugihara's newest illusion showcases a mirror that fails to reflect half of a solid object sitting in front of it. Hold off on the garlic necklace and holy water, though: once again, it's a matter of perspective. The lower—and nonreflected—part of the image is a 2-D drawing that lies flat on the ground and appears to take up volume only from a particular vantage point. To make your own half-disappearing hexagon, follow the link labeled "Fourth Generation: Partly Invisible Objects" at Sugihara's Web site. To achieve the best effect, tilt the mirror slightly downward.

TWIN LAMPS?

Psychologist F. Richard Ferraro of the University of North Dakota and his wife, Jacqueline Lee Foster Ferraro, were remodeling their kitchen when they discovered an intriguing illusion. Look at the picture to the right. Do you see two separate lamps or one lamp reflected in a mirror? Richard Ferraro knew that there were two lamps because he had just moved one of them from the living room to the kitchen. But as he sat down on the living room couch, he could not shake the feeling that he was looking at a single lamp reflected in a mirror (in reality, a pass-through to the kitchen). The couple teamed up with then North Dakota student Cassidy Brougham and showed this same picture to 100 college undergraduates on campus. The team found that 72 people saw one lamp, and 28 saw two. Our visual system's preference for the simplest perceptual explanations for what we see around us, the so-called simplicity principle, may account for this skew.



MORE TO EXPLORE

- **The Venus Effect: People's Understanding of Mirror Reflections in Paintings.** Marco Bertamini et al. in *Perception*, Vol. 32, No. 5, pages 593–599; May 2003.
- **The Venus Effect in Real Life and in Photographs.** Marco Bertamini et al. in *Attention, Perception, & Psychophysics*, Vol. 72, No. 7, pages 1948–1964; October 2010.
- **Ambiguous Cylinders: A New Class of Impossible Objects.** Kokichi Sugihara in *Computer Aided Drafting, Design and Manufacturing*, Vol. 25, No. 4, pages 19–25; 2015.
- **Through the Looking-Glass: Objects in the Mirror Are Less Real.** Preeti Sareen et al. in *Psychonomic Bulletin & Review*, Vol. 22, No. 4, pages 980–986; August 2015.
- **Two Lamps or One? An Illusory Mirror.** F. Richard Ferraro, J. L. Foster Ferraro and Cassidy Brougham in *Perception*, Vol. 45, No. 6, pages 684–686; June 2016.