And Yet It Doesn't Move

How the brain can be fooled into perceiving movement

In August 2014 Nanami "Seven Seas" Nagura walked onto a stage in Oulu, Finland, for what looked like a martial arts demonstration. Flinging her hooded robe to the ground to reveal her kimono, she reached her arm around and prepared to unsheathe her sword. Then she swept a pointed finger out across the crowd and screamed, "I will kill you!"

Explosive light and sound followed. Foo Fighters' hard-driving "Bridge Burning" started cranking while Nagura's blade changed into a hard-rocking guitar. Nagura's left hand fingered the frets as her right arm windmilled Townshend-style. Channeling Hendrix, Nagura ran across the stage as if pulled by her instrument, black tresses whipping back and forth. Bent over backward, toward the audience, she then played the guitar behind her head. The performance was exhausting but worth it: Nagura won the coveted 2014 Air Guitar World Championship. The 19-year-old had achieved air immortality.

But how did we perceive that Nagura wielded a sword and then a guitar, given that neither actually existed? The illusion might have been even stronger had she opted for a more traditional approach, such as sitting on a chair, one foot on a step, hands poised à la Spanish classical guitarist Andrés Segovia. Yet her offbeat performance offered multiple clues that enabled the audience to imagine a solid, moving guitar in Nagura's hands. Put simply: Nagura acted like a rock star, with all the fixings—stage, lighting, music—except the guitar itself.

The brain can derive a lot of information about an object from just a few cues. Implied motion, which is the perception of movement when none is there, is among the most famous examples of this ability. For instance, a drawing of a ball with three horizontal lines just to the right of the ball's edge (*below*) looks like it is flying through the air. Read on to see other examples of the brain's remarkable ability to recognize motion from a few simple clues. **M**

VESA RANTA AP Photo (*Nagura*); SEAN McCABE (*Macknik and Martinez-Conde*)

BY STEPHEN L. MACKNIK AND SUSANA MARTINEZ-CONDE

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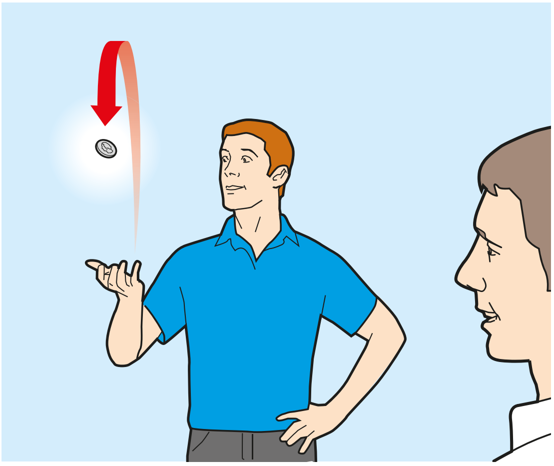
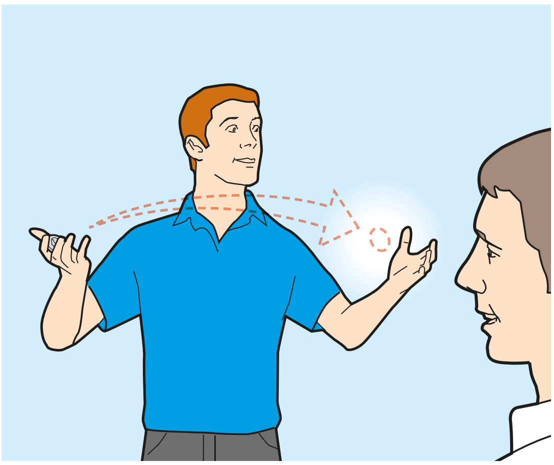




MAGIC MOTION

A few magic tricks take advantage of our brain's propensity to perceive motion based on a handful of implicit cues. Psychologist and magician Gustav Kuhn, then at Durham University in England, studied a magic illusion known as the vanishing ball trick in which a ball thrown in the air disappears in midflight. To achieve this effect, the magician first tosses the ball straight up and then catches it as it drops into his hand several times. On the final pitch, the magician only pretends to throw the ball but in reality keeps it hidden in his hand. Many people see the nonexisting ball ascend and then—alakazam!—vanish in midair.

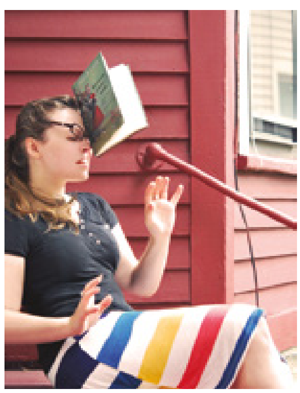
Kuhn and his colleague Michael F. Land of the University of Sussex in England found that the illusion works in part because the magician's head and eyes follow the imaginary ball during the fake toss. The spectators do not direct their gaze along the ball's path, however. The researchers concluded that observers may follow the implied trajectory with their peripheral attention rather than their direct gaze.

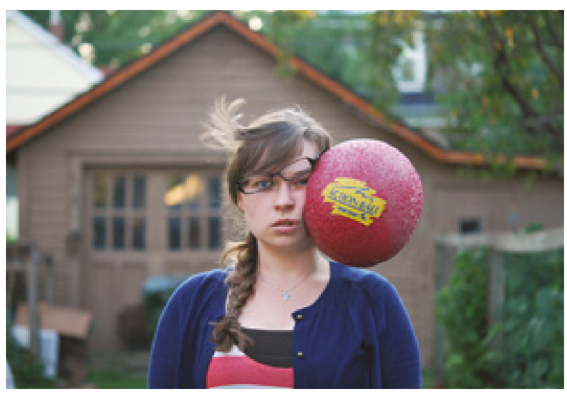
In 2011 we and our colleagues Jie Cui and Jorge Otero-Millan, all then at the Barrow Neurological Institute in Phoenix, teamed up with Mac King, champion comedy magician and headliner at Harrah's Las Vegas, to study a coin-vanishing act. King's sleight of hand technique is the stuff of magic legend. After flipping the coin up and down a couple of times, King then pretends to lob it from right to left while keeping it hidden in his right hand to stop it from flying [*see illustrations at left*]. At the same time, he closes his left hand as if to "catch" the imaginary flying coin. A few breaths later he opens his left hand, and—poof!—the coin, which spectators had just perceived as soaring through the air, is gone.

One reason the implied-motion cues overpower our visual system is that the kinematics of King's simulated throw and catch are very close to the real thing. His timing is perfect: videos that we presented to experimental subjects in the laboratory showed that King grabbed the coin 235 milliseconds after the fake toss and 269 milliseconds after the real toss (the 34-millisecond difference is negligible to our visual system).

In addition, the illusion was equally powerful whether King's face was visible or invisible to observers during the toss, which means that social cues, such as the magician's gaze direction, were less important in this illusion than in Kuhn's vanishing ball trick. The implied action, suggested by the gestures of King's hands, was all that a viewer's brain needed to supply the coin.

FAKED COLLISIONS

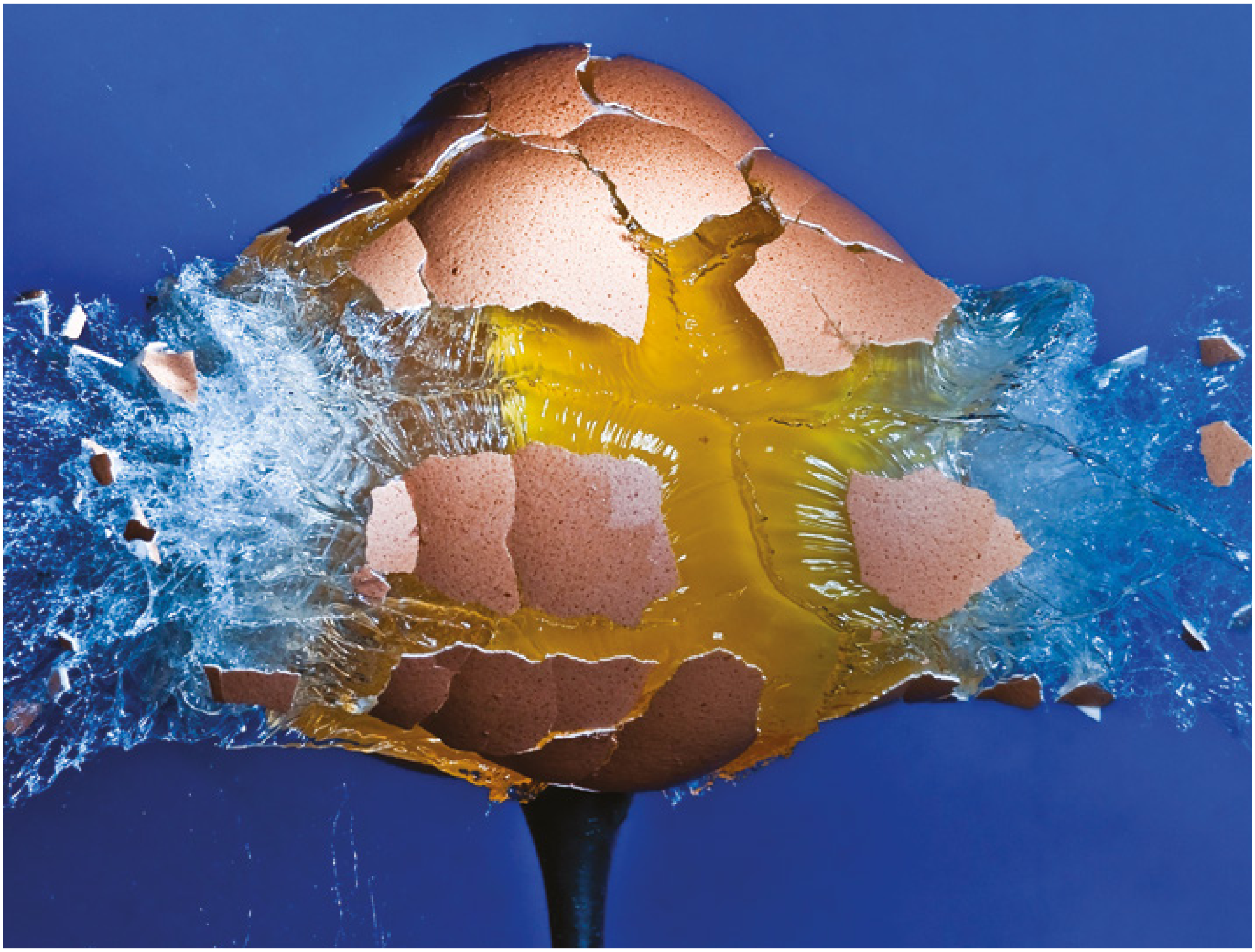




JASON LEE (*top*); KAIJA STRAUMANIS (*bottom*)

Air guitarists and magicians use the shifts of their bodies to create the illusion of imaginary moving objects. But as any reader of superhero comic books knows, a completely still image can convey forceful action. Kaija Straumanis, a photographer and editor at Open Letter Books in Rochester, N.Y., decided to produce 365 photographs of herself getting clocked in the noggin with assorted objects. She cleverly staged implied collisions by taking a series of photographs, including shots in which she held an object against her head, then used photo editing to combine her images. The finished pictures, which she posted to Flickr, show the young woman, sometimes shocked, occasionally unperturbed, at the moment of apparent impact.

The images include many clues that signal motion to our visual system. For instance, Straumanis's left cheek deforms as her face absorbs the crash of a red rubber ball. Straumanis's ash-blonde bangs fly up and her black-frame glasses are knocked askew by the implied impact. The effect activates not only neural circuits that we use to perceive motion but also our mirror neuron system, which allows us to imagine another person's experience [see "A Revealing Reflection," by David Dobbs; Scientific American Mind, April/May 2006]. Although we know that the photographer suffered no harm, it is hard to repress a visceral "ouch" when seeing the images.



ALAN SAILER *Corbis*

FAST AND FURIOUS

Neuroscience has begun to show how implied motion is processed in the brain. Groups of neurons in specific areas encode certain perceptions. When one group of neurons becomes active, we have a certain experience, whereas when a different population of neurons fire, we feel something else. This system allows the brain to assign meaning to objects and events, even when that concept is only suggested by a few sparse cues.

In 2000 neuroscientist Carl Senior, then at King's College London, and his colleagues showed what happens in the brain when we view actual moving objects versus static representations of moving objects. Area MT, a brain region that processes the direction of objects in real motion, responded to both explicit and implicit representations of mobility. That is, neurons in this region reacted not only to an actual ball moving to the left but also to the representation of a static ball with adjacent lines drawn to represent motion and even to a verbal statement that a ball was going along.

The brain sorts out—based on previous experience with this type of representation—that the lines indicate the retinal smearing caused by a rapid advance. Blur in a photograph, as in the exploding egg above, creates the same effect. This knowledge activates a constellation of neurons in the brain, including those that respond to actual moving objects.

FURTHER READING

- **The Functional Neuroanatomy of Implicit-Motion Perception or "Representational Momentum."** C. Senior et al. in *Current Biology,* Vol. 10, No. 1, pages 16–22; January 1, 2000.
- **Remembering Visual Motion: Neural Correlates of Associative Plasticity and Motion Recall in Cortical Area MT.** Anja Schlack and Thomas D. Albright in *Neuron,* Vol. 53, No. 6, pages 881–890; March 15, 2007.
- **Towards a Science of Magic.** Gustav Kuhn, Alym A. Amlani and Ronald A. Rensink in *Trends in Cognitive Sciences,* Vol. 12, No. 9, pages 349–354; September 2008.
- **Attention and Awareness in Stage Magic: Turning Tricks into Research.** Stephen L. Macknik et al. in *Nature Reviews Neuroscience,* Vol. 9, pages 871–879; November 2008.
- **Social Misdirection Fails to Enhance a Magic Illusion.** Jie Cui et al. in *Frontiers in Human Neuroscience,* Vol. 5, Article No. 103. Published online September 29, 2011.