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Magic and the Brain: Teller Reveals the Neuroscience of Illusion

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One of the first tricks in Penn and Teller's Las Vegas show begins when Teller—the short, quiet one—strolls onstage with a lit cigarette, inhales, drops it to the floor, and stamps it out. Then he takes another cigarette from his suit pocket and lights it.

No magic there, right? But then Teller pivots so the audience can see him from the other side. He goes through the same set of motions, except this time everything is different: Much of what just transpired, the audience now perceives, was a charade, a carefully orchestrated stack of lies. He doesn't stamp out the first cigarette—he palms it, then puts it in his ear. There is no second cigarette; it's a pencil stub. The smoke from the first butt is real, but the lighter used on the pencil is actually a flashlight. Yet the illusion is executed so perfectly that every step looks real, even when you're shown that it is not.

Penn and Teller demonstrate the seven basic principles of magic.

The trick is called Looks Simple, and the point is that even a puff on a cigarette, closely examined, can disintegrate into smoke and mirrors. "People take reality for granted," Teller says shortly before stepping onstage. "Reality seems so simple. We just open our eyes and there it is. But that doesn't mean it is simple."

For Teller (that's his full legal name), magic is more than entertainment. He wants his tricks to reveal the everyday fraud of perception so that people become aware of the tension between what is and what seems to be. Our brains don't see everything—the world is too big, too full of stimuli. So the brain takes shortcuts, constructing a picture of reality with relatively simple algorithms for what things are supposed to look like. Magicians capitalize on those rules. "Every time you perform a magic trick, you're engaging in experimental psychology," Teller says. "If the audience asks, 'How the hell did he do that?' then the experiment was successful. I've exploited the efficiencies of your mind."

Now that on-the-job experimentation has taken an academic turn. A couple of years ago, Teller joined a coterie of illusionists and tricksters recruited by Stephen Macknik and Susana Martinez-Conde, researchers at the Barrow Neurological Institute in Phoenix, Arizona, to look at the neuroscience of magic. Last summer, that work culminated in an article for the journal *Nature Reviews Neuroscience* called "Attention and Awareness in Stage Magic." Teller was one of the coauthors, and its publication was a signal event in a field some researchers are calling magicology, the mining of stage illusions for insights into brain function.

"Tricks work only because magicians know, at an intuitive level, how we look at the world," says Macknik, lead author of the paper. "Even when we know we're going to be tricked, we still can't see it, which suggests that magicians are fooling the mind at a very deep level." By reverse-engineering these deceptions, Macknik hopes to illuminate the mental loopholes that make us see a woman get sawed in half or a rabbit appear out of thin air even when we know such stuff is impossible. "Magicians were taking advantage of these cognitive illusions long before any scientist identified them," Martinez-Conde says.

For sleight-of-hand master Teller, magic is a form of experimental psychology.

Photo: Carlos Serrao

Penn and Teller are an *n* of 1 in American culture: avant-garde artists who perform for the Vegas masses, skeptical philosophers who somehow got a cable TV show. For the past 25 years, they've played the same characters onstage. Teller is the silent, impish illusionist—"People are always surprised that I can speak," he says—while Penn is the hyperkinetic impresario, juggling knives, teasing the audience, and swallowing fire. These personae reflect the men's offstage personalities. Penn Jillette is 67", with a mane of curly black hair. When he walks, he pounds the floor like a clown in oversize shoes—not surprising, since he graduated from the Ringling Bros. and Barnum & Bailey Clown College. Teller is nearly a foot shorter and dresses in dapper three-piece suits. He has an eerie grace, as if he can move without displacing air.

The two started performing together in 1975, playing Philadelphia street corners and Renaissance festivals. Along with a third artist, they called themselves the Asparagus Valley Cultural Society, an absurdist act that mixed knife-juggling with "unusual and disgusting" classical music. They were not especially popular. "I always assumed I'd spend my life happily performing in artsy-fartsy little theaters," Teller says.

After their first Renaissance gig, where Teller performed in tights and Penn in leather, they were headed back to New Jersey. To kill some time in a diner, Teller was practicing his version of Cups and Balls, a classic sleight-of-hand trick popularized by ancient Roman conjurers. It involves a series of "vanishes" and "transpositions" as the balls appear and disappear underneath the cups. Teller hadn't brought any props, so he used wadded-up napkins and clear water glasses.

Penn & Teller demonstrate their version of Cups and Balls.

Somehow, this made the trick even better. Although it was now possible to follow the crumpled napkins as Teller variously palmed them, squished them, and moved them from cup to cup, the illusion persisted. "The eye could see the moves, but the mind could not comprehend them," he says. "Giving the trick away gave nothing away, because you still couldn't grasp it." They eventually worked this version of Cups and Balls into their show, and audiences loved it. But the magic community—whose cardinal rule is "Don't tell 'em how it's done"—reacted with outrage and even threats of physical violence. Penn and Teller were exposing an ancient secret! Two arty geeks were destroying the mystery!

All that criticism got press attention, which made people want to see Penn and Teller even more. Before long, they were performing Cups and Balls on *Letterman*. The trick became a centerpiece of their first off-Broadway show. "It was so liberating to be able to treat the audience like intelligent adults," Teller says. Instead of engaging in the "usual hocus-pocus clichés," the clear cups forced the crowd to confront the real source of the illusion: the hard-wired limitations of their own brains. Because people were literally incapable of perceiving the sleight of hand—Teller's fingers just moved too fast—it didn't matter that the glasses were transparent.

Penn and Teller still perform Cups and Balls—it's one of the few old bits in their current Vegas show. Several of their other pieces take a more direct cue from research on perception. In the Cowboy trick, an individual from the crowd is given a video camera; Penn says he's going to make a tiny plastic cow disappear from his hand, and he asks the audience member to film the vanish as the feed is projected onto a large screen for the rest of the room. While the mark focuses on Penn's flamboyant hand gestures—and the impertinently nonvanishing cow—Teller rearranges the entire stage in plain view. The audience cracks up; even when the poor sap looks up from the viewfinder, he fails to notice that anything is different.

Richard Wiseman demonstrates the Colour Changing Card Trick.

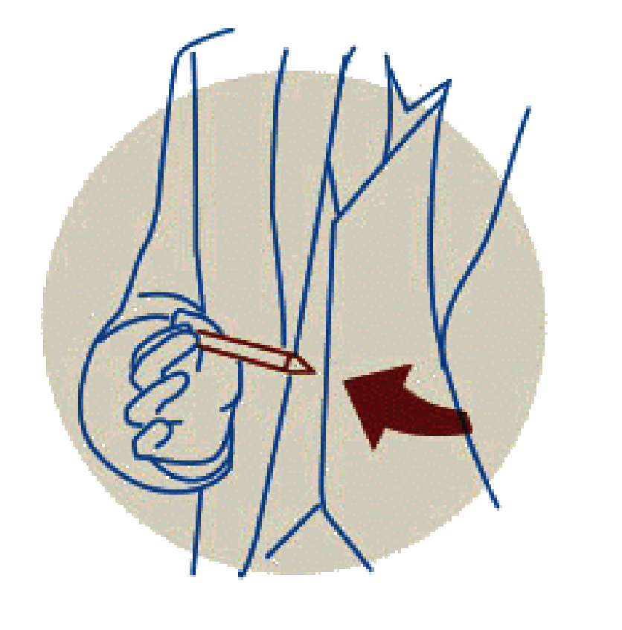
"The idea for this trick came straight from science," Teller says. "We thought it would be fun to show people how bad they are at noticing stuff." Called change blindness, the phenomenon is illustrated in a video (on YouTube) that inspired the duo. Shot in 2007 by British psychologist Richard Wiseman, it ostensibly documents a simple card trick—the backs of the cards in a deck are magically transformed from blue to red. But during the course of the video, Wiseman's shirt, his assistant's shirt, the tablecloth, and the backdrop all change color, too. Most viewers watch the card trick unspool and miss the other alterations. Attention, it turns out, is like a spotlight. When it's focused on something, we become oblivious to even obvious changes outside its narrow beam. What magicians do, essentially, is misdirect—pivot that spotlight toward the wrong place at the right time.

Looks Simple, Doesn't It?

In their Las Vegas act, Penn narrates each step while Teller demonstrates how something as banal as lighting a cigarette can turn out to be an illusion. What appears to be a cigarette is actually a pencil stub. What the audience thinks is a lighter is really a tiny flashlight. The trick illustrates the seven basic principles of magic: palm, ditch, steal, simulation, load, misdirection, and switch.

1. PALM
lit cigarette.

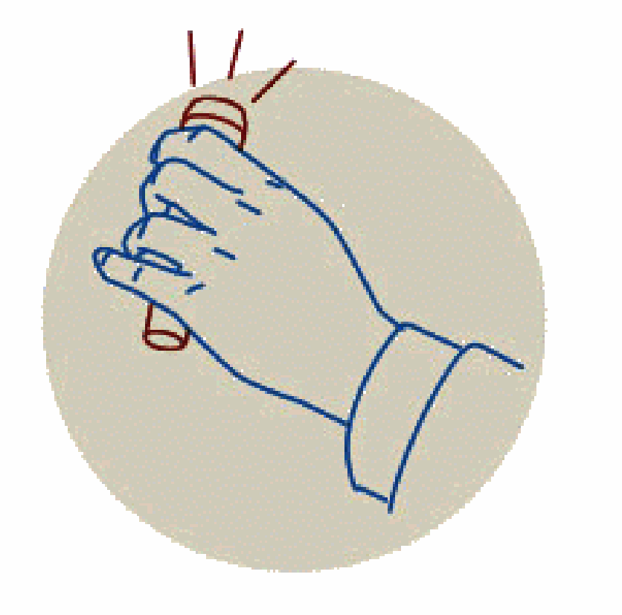
2. DITCH
cigarette in ear.



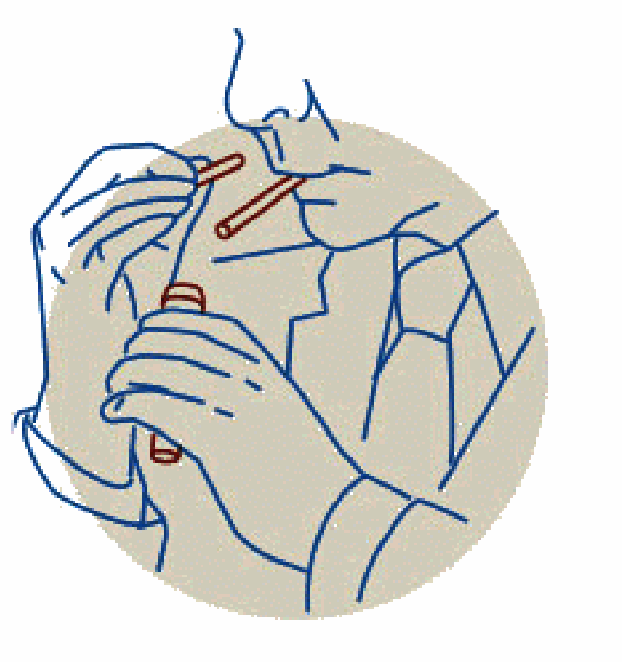
3. STEAL
pencil stub.

4. SIMULATE
pulling out cigarette.

5. LOAD
real cigarette.



6. MISDIRECT
with flashlight.



7. SWITCH
pencil for cigarette.

During Penn and Teller's show, the audience laughs at the patsy onstage. But that part of the act is clearly intended as an indictment of human perception. "The irony," Teller says, "is that what we're doing to the volunteer is the same thing we've been doing to the crowd all night."

Teller designed his own house in the Las Vegas foothills, and he delights in showing first-time visitors around. He starts the tour by pointing down a hallway at a window, through which I see a beautiful view of the sprawling neon city below.

"Go take a look," Teller says. I amble down the hall and—just before reaching the end—smack into something hard, leaving a wet mouth-print on polished glass. The "window" is merely a reflection; the hallway ends in a precisely angled, mirrored door. "You didn't see the illusion because you weren't expecting one," Teller says. "You assumed I wasn't fucking with your head and that this hallway is actually a normal hallway. Those assumptions work great until you walk into a wall."

The fake window is only the beginning. The house also has a bookcase that's actually a door, lightbulbs that appear to change color mysteriously, and a bronze bear statue that tells you what card you're thinking of. After demonstrating that last prank, Teller watches as I try in vain to figure out how it's done. He relishes the confusion of his audience—and even fellow illusionists: "I had Criss Angel over here; he couldn't figure out how the bear worked, either." Unless Teller sees the symptoms of astonishment—mouth agape, eyes widened, pupils dilated—he doesn't consider the trick a success. "The magic show is a competition," he says. "The audience is trying to figure you out. They aren't suspending their disbelief—they're trying to expose you as a scam artist." This is what makes magic so difficult: The magician must sell people a lie even as they know they're being lied to. Unless the illusion feels more real than the truth, there is no magic.

What's surprising is just how limited the repertoire of magical illusions actually is. The *Nature Reviews Neuroscience* paper lists nine fundamental "conjuring effects" of modern magic, from the vanish and the restoration to telekinesis and ESP. While these basic tricks have been varied endlessly—you can "restore" a cut rope, a sawed-in-half assistant, a shredded piece of paper—each of the effects relies on a specific perceptual phenomenon. This may be why exposing the "secret" of a magic trick is so often deflating. Most of the time, the secret is that we're gullible and our brains are riddled with blind spots.

This isn't just the stuff of magic shows; those perceptual phenomena also allow us to make sense of reality, as we translate the blur of photons hitting our retinas into a coherent world of three-dimensional forms.

Consider a technique used by the legendary pickpocket Apollo Robbins, another coauthor of the *Nature* article spearheaded by Macknik and Martinez-Conde. When the researchers asked him about his devious methods—how he could steal the wallet of a man who *knew* he was going to have his pocket picked—they learned something surprising: Robbins said the trick worked only when he moved his free hand in an arc instead of a straight line. According to the thief, these arcs distract the eyes of his victims for a matter of milliseconds, just enough time for his other hand to pilfer their belongings.

At first, the scientists couldn't explain this phenomenon. Why would arcs keep us from looking at the right place? But then they began to think about saccades, movements of the eye that can precede conscious decisions about where to turn one's gaze. Saccades are among the fastest movements produced by the human body, which is why a pickpocket has to trick them: The eyes are in fact quicker than the hands. "This is an idea scientists had never contemplated before," Macknik says. "It turns out, though, that the pickpocket was onto something." When we see a hand moving in a straight line, we automatically look toward the end point—this is called the pursuit system. A hand moving in a semicircle, however, seems to short-circuit our saccades. The arc doesn't tell our eyes where the hand is going, so we fixate on the hand itself—and fail to notice the other hand reaching into our pocket. "The pickpocket has found a weakness in the way we perceive motion," Macknik says. "Show the eyes an arc and they move differently."

While the magicians are educating the scientists, so far the scientists haven't offered much in return. Cowboy trick aside, Teller says, "this is an example of entertainers getting there first." And he wishes it weren't so. Teller hopes that laboratory insights will offer ways to break free of the stale tricks that have defined magic for decades—much as new technologies made possible the illusions of David Abbott in the early 20th century. A loan shark in Omaha, Nebraska, Abbott performed innovative, late-night shows in his living room. (Harry Houdini was one of many magicians who made the pilgrimage.) "Abbott used to say he wasn't satisfied with a trick unless people began to weep," Teller says. "He was that good."

Abbott's audiences were practically preindustrial—all it took to fool them into thinking that spirits move among us was a radio receiver wired into a papier-màché teakettle. Today's consumers of illusion are both hungrier for deception and savvier about its practice, a dichotomy due in no small part to Penn and Teller's own acts over the years. Teller has spent enough time with researchers to think they might be the key to an entirely new category of stage magic—that the quirks and flaws of perception uncovered in the lab can be commercialized, essentially, into illusions for an ever more sophisticated audience. "Maybe I'll learn something from these scientists," he says with a wry smile. "Maybe one of their discoveries will inspire a new kind of illusion. Maybe that's how I'll make people cry." Until he shows them how it's done.

Jonah Lehrer (jonah.lehrer@gmail.com), *author of* How We Decide *and* Proust Was a Neuroscientist, *wrote about the Allen Brain Atlas in issue 17.04.*

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