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COVER IMAGE BY AARON GOODMAN

Presto!

The hat with the fake bottom, which conceals a rabbit. The handkerchiefs tucked up one sleeve. And the box that has fake feet sticking out of one end, so the lady can be "sawed" in half (actually, she's curled safely in one side). We think we know some of the common tools in the magician's bag of tricks. But what we haven't noticed—because of their deceptive skill—is that their number-one sleight facilitator is our own, untrustworthy mind.

Over many years conjurers have honed the high art of manipulating our brains. They deliberately divert our attention and focus to fool us with their delightful capers. An innocent-looking adjustment of eyeglasses with one hand can conceal a smooth movement by the other to hide a coin. Magicians' "field research" has only recently become appreciated by neuroscientists working in labs—who use different means but who also study attention and awareness, a facet of the study of consciousness and one of the hottest areas of neuroscience.

Working with performers, neuroscientists are probing the neural correlates of attention. To learn more, turn to page 22 for our cover story, "Mind over Magic?" by neuroscientists Stephen L. Macknik and Susana Martinez-Conde. On www.ScientificAmerican.com/Mind, we also feature a video demonstration with the authors and the "gentleman thief" Apollo Robbins.

What is the trick to raising children well? Psychologist Robert Epstein offers 10 essential skills in "What Makes a Good Parent?" on page 46. Some will surprise you. It may be obvious that every child needs love, but did you know that how you treat your partner—and yourself—matters a lot? Children do not like conflict, and how you handle stress is not just your problem. Parents who cope well tend to have better relationships with their kids. Fortunately, we can all learn ways to help manage life's pressures, such as meditation. You might even consider taking in a magic show.

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FEATURES

Mind *over* Magic?

Magicians dazzle us by exploiting loopholes in the brain's circuitry for perceiving the world and paying attention

By Stephen L. Macknik and Susana Martinez-Conde, with Sandra Blakeslee

Excerpted from *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions*, by Stephen L. Macknik and Susana Martinez-Conde, with Sandra Blakeslee, by arrangement with Henry Holt and Company, LLC (US) and Profile Books (UK).

Apollo Robbins, master pickpocket and celebrity magician, is sweeping his hands around the body of the fellow he has just chosen from the audience. "What I'm doing now is fanning you," he informs his mark, "just checking to see what you have in your pockets." Apollo's hands move in a flurry of gentle strokes and pats over the man's clothes. More than 200 scientists are watching him like hawks, trying to catch a glimpse of fingers trespassing into a pocket. But to all appearances this is a perfectly innocent and respectful frisking. "I have a lot of intel on you now," Apollo continues. "You scientists carry a lot of things."

Apollo is demonstrating his kleptic arts to a roomful of neuroscientists who have come to Las Vegas for the 2007 Magic of Consciousness Symposium. Magicians and neuroscientists share a passion for understanding the nuts and bolts of the human mind, but we have been developing our respective arts and theories more or less independently of each other for generations. Starting tonight, if all goes as planned, our two communities are going to pay close attention to each other's discoveries.

As vision scientists, we have spent the past few years traveling the world, meeting magicians, learning tricks and inventing the science of "neuromagic." Magic tricks work because humans have a hardwired process of attention and awareness that is hackable. By understanding how magicians hack our brains, we can better understand how the same cognitive tricks are at work in advertising strategy, business negotiations and all varieties of interpersonal relations.

Magicians distract and fool an audience by surreptitiously manipulating people's attention, tricking them into focusing on irrelevant objects or occurrences and into making incorrect assumptions about the purpose of an action. These artists construct various types of cognitive illusions [*see box on page 27*] that make it impossible for the uninitiated to follow the physics of what is actually happening. As a result, observers get the impression that there is only one explanation for what just took place: pure magic.

AARON GOODMAN

Apollo Robbins, the infamous "gentleman thief," manipulates people's attention in clever ways to prevent them from noticing when he absconds with their wallets, watches, keys, eyeglasses and cash.

Cognitive Feints and Jabs

Apollo has dared everyone in the auditorium to try and catch him pilfering this man's belongings. We watch intently, but none of us really stands a chance. This is Apollo Robbins, the infamous "gentleman thief" who once pickpocketed ex-president Jimmy Carter's Secret Service detail, relieving them of their watches, wallets, badges, confidential itinerary and the keys to Carter's limo. But as soon as we see whom Apollo has plucked randomly from the crowd, we exchange amused glances. This man isn't a scientist at all, as Apollo assumes, but *New York Times* science reporter George Johnson.

The fanning continues as Apollo engages in his highly honed rapid-fire patter. "You have so many things in your pockets I'm not sure where to begin. Here, was this yours?" he asks, thrusting something into George's hand. George frowns down at it. "You had a pen in here," Apollo says opening George's breast pocket, "but that's not what I was looking for. What's in that pocket over there?" George looks over. "There was a napkin or a tissue, maybe? You have so many things it's confusing to me. You know, to be honest I'm not sure that I've pickpocketed a scientist before. I've never had to do indexing as I went through someone's pockets."

Patter is one of the most important tools in the magician's toolkit for attention management. There are only a dozen or two (depending on whom you ask) main categories of effects in the magician's repertoire; the apparent wide variety of tricks is all in the presentation and details. Sleight of hand is of course critical to a pickpocket, but so is patter—the smooth and confident stream of commentary that can be used to hold, direct or divide attention. Apollo tells George one thing while doing two other things with his hands. This means that in the best-case scenario George has only a one-in-three chance of noticing when something of his gets snatched. His real chances are actually far below one in three: in the psychic sparring ring of attention management, Apollo is a 10th-degree black belt. By continually touching George in various places—his shoulder, wrist, breast pocket, outer thigh—he jerks George's attention around the way a magnet draws a compass needle. While George is trying to keep track of it all, Apollo is delicately dipping his other hand into George's pockets, using his fast-driving voice to help keep George's attention riveted on Apollo's cognitive feints and jabs and away from the pockets being picked.

SPOILER ALERT!
The following section describes magic secrets and their brain mechanisms!

Apollo steals George's pen, notes, digital recorder, some receipts, loose cash, wallet and, very early on, his watch. One classic way to lift somebody's watch is to first grab their wrist over the watchband and squeeze. This creates a lingering sensory afterimage, a tactile one in this

COURTESY OF APOLLO ROBBINS (*Apollo Robbins*); PETER STACKPOLE *Time & Life Pictures/Getty Images* (*wristwatch trick*)

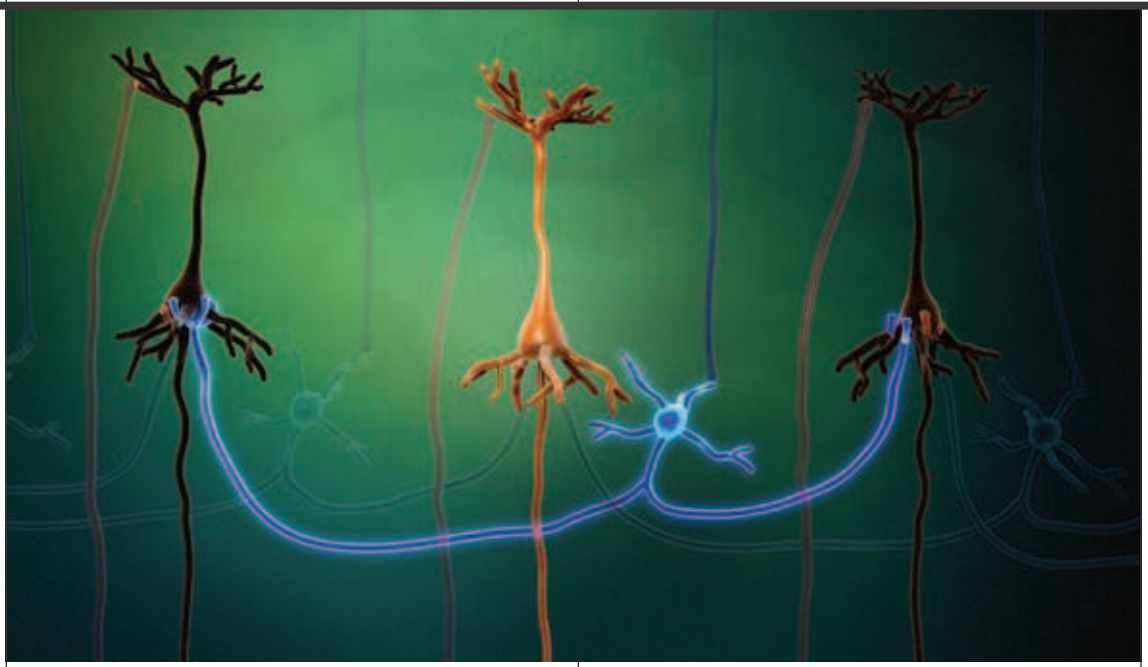
FAST FACTS

Shifting Focus

1» Humans have a hardwired process of attention and awareness that is hackable.

2» When people focus on one thing, their brains automatically suppress everything that happens around it. Magicians have devised many techniques that exploit this "tunnel vision."

3» People can pay attention in various ways. Magicians exploit "top-down," or deliberate, attention by, say, asking a person to scan a book. They capture "bottom-up" attention with distracting displays such as doves fluttering out of a hat.



When something grabs your attention—say, you spot a friend across the street—the specific neurons governing perception of that region of visual space (*orange*) become activated. Simultaneously, inhibitory neurons (*blue*) suppress the nearby brain cells responsible for perceiving surrounding areas (*dark brown*). Thus, paying attention to one thing makes it harder to notice what is around it: while you are focusing on your friend, you will fail to notice the cat slinking past you on the sidewalk.

COURTESY OF THE BARROW NEUROLOGICAL INSTITUTE

case. The afterimage renders the touch neurons in George's skin and spinal cord less sensitive to the watch's removal and creates a conveniently lasting perception of the watch long after it has disappeared. George simply doesn't notice his watch is missing because his skin tells him it is still there. We notice the watch when we see Apollo folding his arms behind his back, buckling it onto his own wrist as his patter leads George down some new garden path of attention.

END OF SPOILER ALERT

A few times during the fleecing Apollo holds up a pilfered object high behind George's head for the audience to see. This makes everyone but George laugh, who smiles and looks around sheepishly, wondering what the joke is. Then, to more laughter, Apollo returns all George's belongings one by one. Finally, he turns to George and says, "We all pitched in to buy you a watch, very similar to the one you were wearing when you got here." He unstraps George's watch from his own wrist and passes it over. George gasps and then rolls his eyes. How could he be so inattentive?

Dissecting Attention

Possibly the best definition of attention was put forth in 1890 by William James, the philosopher king of modern psychology. He wrote: "Everyone knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others."

By continually touching George in various places—his shoulder, wrist, breast pocket, thigh—Apollo jerks George's attention around the way a magnet draws a compass needle.

Since James's day, neuroscientists have learned that attention refers to a number of different cognitive processes. You can pay attention to your TV show voluntarily, which is one process (top-down attention), or your baby's crying can draw your attention away from the TV, a different process (bottom-up attention). You can look right at what you are paying attention to (overt attention), or you can

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look at one thing while secretly paying attention to something else (covert attention). You can draw somebody's gaze to a specific object by looking at it (joint attention), or you can simply not pay attention to anything in particular. Some of the brain mechanisms controlling these processes are beginning to be understood. For example, you have a "spotlight of attention" that restricts how much information you can take in from a region of visual space at any given time. When you attend to something, it is as if your mind aims a spotlight onto it. You actively ignore virtually everything else, giving you a kind of "tunnel vision." Magicians exploit this feature of your brain to maximum effect.

It is not yet clear whether there is a single center in your brain that controls attention. Given the many types of attention, multiple attention-control centers may work in concert. One critical clue is that many of the same brain circuits that control your eye movements are involved with changing the location of your attention in the world. Eye movement circuits are responsible for orienting your eyes to specific areas of visual space, so it seems logical that those same circuits could orient your attentional spotlight, too. Determining what is interesting in the world is undoubtedly critical to deciding where you should look next. Magicians intuitively grasp this and control your eyes and your attention as if they were marionettes on a string.

Magicians may actively misdirect a person's attention toward a random object—say, asking him or her to identify the year on a quarter—so that they can perform another action unnoticed.

GETTY IMAGES

"Try these glasses," Apollo offers as he hands you the glasses off his face. Your own glasses, it turns out. While you were focused on the quarter, Apollo took the glasses from your pocket.

Attention is also linked to your short-term memory and your ability to tune out your focus on what is happening around you. Sometimes a stimulus is so demanding, so salient, that you cannot help but pay attention—an ambulance siren, an infant's cry, a dove fluttering out of a top hat. This information flows in a bottom-up fashion—from your primary senses to higher levels of analysis in your brain. It is called sensory capture.

Other times you can shift your attention around, as you choose, in a top-down fashion. Signals flow from your prefrontal cortex (the CEO of your attentional networks) to other regions that help process information. You don't hear the siren or baby or see the dove, because you are attending to something else, such as the last page of that fabulous mystery novel you are reading. Research shows that the greater your capacity for short-term or working memory, the better you are at resisting sensory capture.

Neuroscientists have begun to dissect the nature of attention and identify its neural correlates. The initial brain areas that process a visual scene use circuits that lay out visual space like a map. When you decide to consciously pay attention to a specific location of this "retinotopic" space, neurons from higher levels of your visual system increase the activation of the low-level circuits and enhance their sensitivity to sensory input. At the same time, neurons in the surrounding regions of visual space are actively inhibited. We recently worked with a group led by neuroscientist Jose-Manuel Alonso of the S.U.N.Y. State College of Optometry and showed that the neurons in the primary visual cortex not only exhibited this center-surround pattern of activity during

Mental Marksmanship

Magicians employ psychologically sophisticated tactics to train the focus of an audience away from the real action, enabling them to perform "magical" moves behind an audience's back—or, more often, right in front of its eyes. Their mental maneuvers include:

Afterimages. Magicians may poke or press a person to simulate the presence of an imaginary object they say they are providing or a real one they intend to remove, leaving the impression that the object is on the body when it isn't.

Patter. By engaging in chitchat, the magician fills an observer's mind with irrelevant information, creating confusion that distracts from the action.

Passive misdirection. Bright, new, moving or flashing objects on stage draw attention, something scientists call sensory capture.

Active misdirection. A performer may tell a volunteer to perform an irrelevant action, thereby putting the focus on that activity.

Time misdirection. A delay between the method behind a trick and its effect prevents people from linking the two.

A decoy action with an apparent purpose, such as adjusting a hat, can disguise a related, more surreptitious maneuver. Did the magician slip something under the brim?

Decoy actions. If an action seems to have an obvious purpose, such as scratching an itch or adjusting a hat, an audience generally will not notice that a magician has, say, used the move to put an object under the hat or behind his ear.

attentional tasks but that the degree of the activation was modulated by the amount of effort used to accomplish a task. The harder the task, the more the central region of attention was activated and the more the surrounding region was suppressed.

In a magic show, you face an incredibly difficult task: to peel away all the layers of misdirection and figure out the secret method underlying each magic effect. But the harder you try, the harder it gets: the more your attention is enhanced on the center of the attentional focus, the more your attention is suppressed in all other locations. Of course, the center of the attentional focus is right where the magician wants it—where nothing of particular interest is going on. The locations surrounding your spotlight of attention—where the real action is happening—are now conveniently suppressed by your brain. The armies of neurons that suppress perception in those regions are the magician's confederates.

What Year Is the Coin?

Apollo works his marks as if he knew about these neuronal circuits all along. He'll pull a quarter from your breast pocket and ask, "Is this yours?" You know full well that it's not yours (nobody holds their quarters in their breast pocket). But you can't help it, you inspect George Washington's face as if you might find your initials engraved on his forehead. "What year is the coin?" Apollo asks. And you dutifully try to find out, but the letters are too small and blurry so you reach for your reading glasses … in your breast pocket. They are missing. "Try these glasses," Apollo kindly offers as he hands you the glasses off his face. Your own glasses, as it turns out. While you were busy attending to the quarter, which you should have known didn't actually come from your pocket, Apollo's hands absconded with those glasses literally right under your nose while you suppressed all visual motion surrounding the quarter.

After fleecing George, Apollo turns to the audience and asks, "Now would you like to see the behind the scenes of how I did all that?" Magicians are famously loath to give away their secrets, but Apollo is here in Las Vegas tonight to instruct, not just to entertain.

AARON GOODMAN

➥For a live demonstration of how magicians fool our brains, visit **www.ScientificAmerican.com/Mind/magic**

SPOILER ALERT!
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"Frames" are windows of space that the magician creates to localize your attention. A frame can be the size of a whole room or a tabletop or no bigger than a business card. "You have no choice but to watch in the frame," Apollo says. "I use movement, context and timing to create each frame and control the situation." Apollo demonstrates by moving very close to George. He grabs George's hand and pretends to press a coin into it, although all he is really placing there is another sensory afterimage with his thumb. "Squeeze hard," Apollo instructs. George gazes intently at his hand, now caught within a frame. He squeezes. "Do you have the coin?" Apollo teases. George nods. He thinks so. "Open your hand," Apollo says. The palm is empty. "Look on your shoulder," Apollo suggests. George glances to his shoulder where a coin is resting.

Apollo explains that if a subject's attention is localized to a frame, then maneuvers outside the frame will rarely be detected (such as placing a coin on a shoulder). Magicians, he says, thoroughly manage attention at all times. People tend to think of "misdirection" as the art of making someone look to the left while some fast move is pulled on the right, but Apollo says it is more about force-focusing your spotlight of attention to a particular place and at a particular time.

Magicians exploit several psychological and neural principles to focus your spotlight of attention. One is sensory capture, which magicians call passive misdirection. When you see an object that is new, bright, flashy or moving—think of that white dove fluttering out of a top hat—your attention is driven by increased activity from your senses that flows up into your brain. In passive misdirection, you are attending to the fluttering bird while the magician gains a few unattended moments to carry out a sneaky maneuver. It is passive because the magician lets you do all the work. He just sets up the condition.

If more than one movement is visible—the flying dove arches overhead while the magician reaches his hand into a box to set up the next trick—you will naturally follow the larger, more salient movement. You track the bird, not the hand. Hence the magician's axiom, "A big move covers a small move." In fact, a large or fast-moving stimulus, such as the fluttering dove, can literally decrease the perceived salience of a small or more slowly moving stimulus, such as the magician's hand in the box, so that your attention is drawn to the bird, not the hand.

Furthermore, things that are novel (the unexpected dove) produce stronger responses in parts of your brain that are critical to the allocation of attention. The salience of an object is also increased when a magician actively directs your attention to it. For example, Apollo may ask you to leaf through the pages of a book while he places your stolen wallet in his pocket. You become absorbed in the task of turning pages. This is active misdirection. Your top-down attentional control is focused on the book, and you ignore the hand.

Apollo messes with your head in other ways as well. His patter aims to generate an internal dialogue in your mind—a conversation with yourself about what is taking place. This, he says, results in a great deal of confusion. It slows your reaction time and leads you to second-guess yourself. Many magicians can also introduce delays between the method behind a trick and its effect, preventing you from linking the two. They call this "time misdirection." Indeed, in many magic tricks the secret action occurs when you think that the trick has not yet begun or when you think that the trick is over.

END OF SPOILER ALERT

Motion with a Purpose

Another important concept, Apollo tells the scientists gathered in Las Vegas, is that tricks are embedded in natural actions. He dangles a pen in front of the audience with one hand. When he flicks his other hand past his ear, as if to scratch, no one notices. The movement is natural, unremarkable, quick. Suddenly, everyone sees the pen has vanished. Apollo turns his head around to reveal the pen tucked behind his ear.

Teller, the shorter half of the duo Penn & Teller, sheds his mute persona to describe the same concept. "Action is motion with a purpose," he says. In normal social interactions, we constantly search for

JOHN LUND Getty Images

While a magician misdirects an audience to look at a large or fast-moving target, such as a dove fluttering overhead, he can invisibly perform smaller, subtler maneuvers such as sliding a card up his sleeve.

GETTY IMAGES

Apollo messes with your head in other ways as well. His patter aims to generate an internal dialogue in your mind that causes confusion and leads you to second-guess yourself.

the purpose motivating other people's actions. An action with no obvious purpose is anomalous. It draws attention. When the purpose seems crystal clear, however, we look no further. Teller explains that he will draw suspicion if he raises his hand for no apparent reason but not if he performs a seemingly natural or spontaneous action such as adjusting his glasses, scratching his head, pulling a pencil out of his pocket, or draping his coat over the backrest of a chair.

Neuroscientists now have a good idea why such decoy actions are so good at fooling us. Brain cells called mirror neurons help us understand the actions and intentions of other people. They do this by automatically mimicking others' actions and assuming their intentions [see "A Revealing Reflection," by David Dobbs; Scientific American Mind, April/May 2006]. So when you see Teller reach for a glass of water, you do the same thing in your mind. You also ascribe a simple motivation to him, namely, that he is thirsty and will raise the glass to his lips and take a drink. Your brain makes a prediction and runs a simulation, automatically and usually subconsciously.

Mirror neurons are part of how we are able to understand one another, to imitate, to learn and teach, to empathize. But they can also mislead us. A good magician can disguise one action as another or convincingly fake an action he isn't really performing, prompting your mirror neurons to feed you false inferences about what he is actually doing or not doing. You see Teller raise the glass to his lips and seem to drink, and your automatic prediction seems to be fulfilled. But did he really take a drink? Maybe he transferred something from hand to mouth or from mouth to hand. **M**

(Further Reading)

- **Mind Tricks.** S. Martinez-Conde and S. L. Macknik in *Nature,* Vol. 448, page 414; July 26, 2007.
- **Attention and Awareness in Stage Magic: Turning Tricks into Research.** S. L. Macknik, M. King, J. Randi, A. Robbins, Teller, J. Thompson and S. Martinez-Conde in *Nature Reviews Neuroscience,* Vol. 9, pages 871–879; November 2008.
- **Magic and the Brain.** Susana Martinez-Conde and Stephen L. Macknik in *Scientific American,* Vol. 299, No. 6, pages 72–79; December 2008.
- Apollo Robbins at the Magic of Consciousness Symposium: **http://sleightsofmind.com/media/magicsymposium/Apollo**