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Mind Over Magic

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

Two cognitive neuroscientists—researchers who study how your brain perceives the world around you—delved into the world of magic to see what they might learn. They discovered that magicians know a thing or two about human behavior. If you don't mind learning the secrets behind a few magic tricks, read on.

Pay Attention!

You can pay attention in lots of ways. *Overt attention* is when you purposefully point your eyes at an object while paying attention to it. *Covert attention* is the act of looking at one thing while paying attention to another. Magicians, diabolical as ever, have taken advantage of the ways your brain pays attention in designing some of their favorite tricks. To describe their methods, we coined the terms *overt misdirection* and *covert misdirection*.

In overt misdirection, the magician moves your gaze away from the method behind the trick. He draws your eyes to something of false interest while he carries out a secret action at another location. This is what most people think of when they hear the word "misdirection." An explosion lights up the stage, and a miniature mushroom cloud billows its way up to the rafters. Whoops! Where did that rabbit come from on the other side of the stage? While you were distracted and looking at the explosion, the magician used any one of a dozen methods to make the rabbit appear.

Covert misdirection is more subtle. The magician draws your attentional spotlight—your focus—away from the method without redirecting your gaze. You may look directly at the method behind the trick, but you are entirely unaware of it because your attention is focused elsewhere. You look, but you do not see.

Cognitive neuroscientists know quite a lot about covert misdirection—it's an important part of *inattentional blindness*. With inattentional blindness, you fail to notice an object that's right in front of your eyes because your attention is directed elsewhere. It has to do with how your brain sees and processes information. We also study a closely related phenomenon called *change blindness*. With change blindness, you do not notice a change in the scene. It has to do with how your mind fails to remember what it has just seen.

The Gorilla in the Room

Several years ago, two of our colleagues, Daniel Simons and Christopher Chabris, designed a brilliant experiment that never fails to shock and delight people who encounter it for the first time. The instructions are simple. You are asked to watch a short video of people passing around a basketball. One team wears white T-shirts; the other wears black T-shirts. Your job is to count the number of passes made by one team, or to keep count of bounce passes versus thrown passes. After three or four minutes, the video

ends and you are asked if you saw anything unusual.

No? Look again. This time the scientist pauses the video at the halfway point. And there, suddenly, inexplicably, you see it—a person dressed up in a gorilla suit, standing smack in the middle of the basketball players, beating its hairy chest, looking right at you. Rewind, and you see the whole impossible action. The gorilla strolls up to the players, turns toward the audience, thumps away, turns, and walks off slowly. Half the people who see this video fail to notice the gorilla.

Why? How could you fail to notice a monstrous ape amid ball-tossing college kids? It's because you are so focused on counting the number of passes that a gorilla is not enough to draw your attention away from the ball. You look right at the hairy beast and do not see it.

The invisible gorilla experiment raises an interesting question. Where are your eyes looking? Is the image of the ball the only thing entering your eyes? Or is the gorilla's image also reaching your eyes but not registering with your brain?

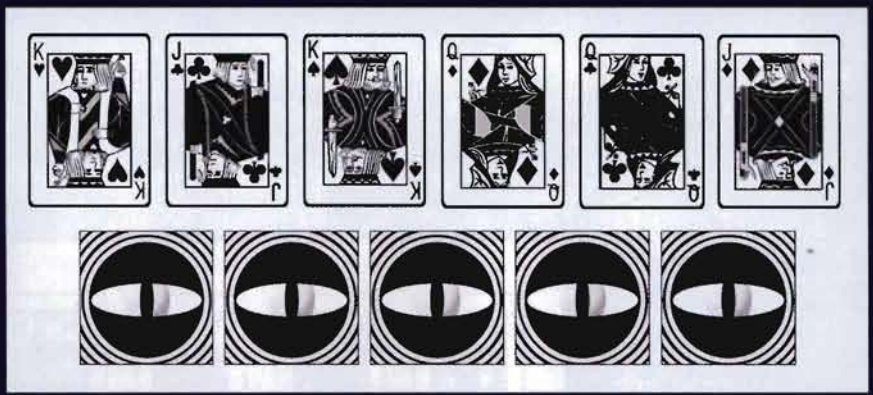
In 2006, Daniel Memmert used eye tracking (a technology that follows a person's pupils to see where she's looking) to show that many people do not notice the gorilla even when they are looking directly at it. In fact, people who miss the gorilla spend just as much time looking at it (around a second) as those who notice it. This was an incredibly surprising discovery. Many neuroscientists had assumed that the gorilla was invisible because the basketball game drew the observers' eyes away from the gorilla. This would be overt misdirection, as when the magician creates an explosion on the stage. Memmert's result showed that they were wrong; it was really *covert* misdirection. The gorilla was invisible even

You can see this video, and other cool demonstrations of change blindness, at www.theinvisiblegorilla.com/videos.html.

Can You Keep Us from Reading Your Mind?

See if you can explain the astounding results of the following mind-reading experiment. It was designed by Clifford Pickover, a prolific author of popular books about science and mathematics. The editors of *Scientific American* prepared a simulated Pickover test that you can take here.*

By using ESP, we think we can predict the outcome of your choice with 98 percent accuracy. To begin, pick one of the six cards below and remember it. Say its name aloud several times so you won't forget it. Once you're sure you'll remember the card, circle one of the eyes in the row below. Then turn the page to see if we're right.



*Pickover's Test is based on a trick invented by Henry Hardin around 1905. Hardin originally called it the Prince's card trick, but over time the title slipped into the Princess card trick, which is now its proper name.

when you looked right at it, because the task of counting basketball passes drew your attention away from the gorilla. The study showed that visual perception is more than just light entering your eyes and activating your brain. To truly see, you must pay attention.

Inattentional blindness—when you miss something in your field of vision by not paying attention—can get you into trouble in everyday life. How often have you been chatting away on a cell phone, only to find yourself walking into another person? In 2009, psychologists at Western Washington University looked at four categories of college students walking across a main campus square. One group simply walked along minding their own business. A second group walked in pairs, talking. A third listened to iPods as they walked. The fourth group was gabbing on cell phones. In each instance, an outrageously costumed clown on a unicycle pedaled up to the students, circled them goofily, and rode off.

Students who walked in pairs were most likely to see the clown. Those using iPods or walking alone were only slightly less attentive. But half of the students talking on cell phones entirely missed the clown on the unicycle. They also walked more slowly, weaving as they crossed the square. The researchers concluded that cell phone conversation leads to inattentional blindness and disrupts attention. It even disrupts walking.

Viewers who focus on counting the basketball passes in this video are often too distracted to notice the gorilla. (The basketball players themselves, though, must have seen it.)

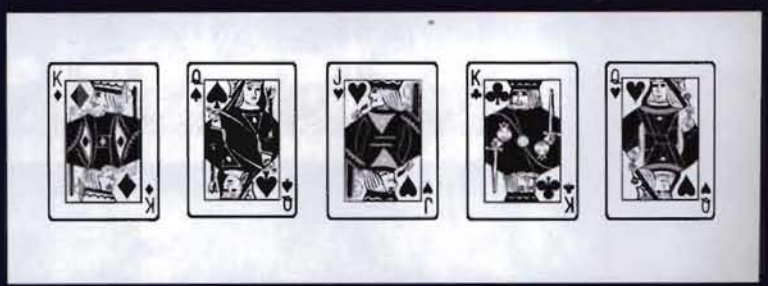
You Can Miss Just About Anything

In the quaint village of Benasque, Spain, we attend an international conference on art and science. An eclectic group of experts have come to explore the limits of human perception. Here, we meet a magician named Miguel Angel Gea whose tricks dazzle the audience more than any discussion of brain research could.

We Read Your Mind!

We have removed your card! Did we guess the card you picked on the previous page? If so, does ESP or magic explain our correct answer? Or is there a simpler explanation? Read no further until you want to know the answer.

Give up? Look over once more at the six cards on the previous page, then compare them with the five cards pictured on this page. Notice any differences? None of the cards are the same! If the act of circling an eye distracted you and you fell for the trick (most people do), you are a victim of what psychologists call *change blindness*. A change—even a big, obvious change—can be all but invisible until you take another look.

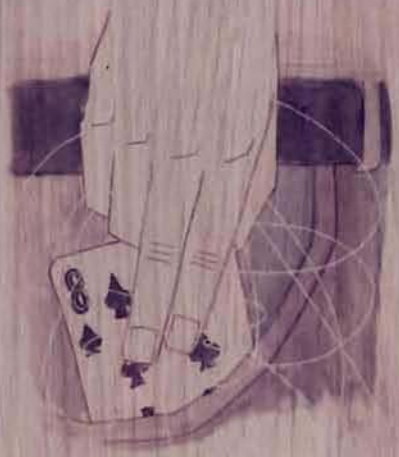


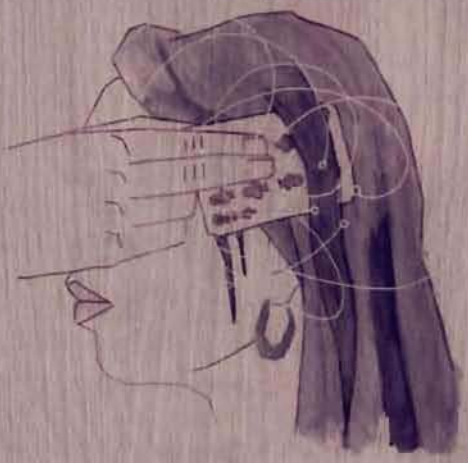
Gea uses the latest cognitive science research to help him develop new tricks. For example, our colleague Dan Simons (of invisible gorilla fame) designed another clever experiment that illustrated change blindness. In one version of the experiment, a professor is observed walking across a college campus. A student walks up to the professor and says, "Excuse me, sir. Can you tell me where the gymnasium is?" He pulls out a campus map. "I don't know my way around."

The professor, who is happy to help, looks down at the map, along with the student, and begins to point the way. But just then two workmen carrying a large rectangular object—sometimes a door, sometimes a large painting—approach and try to get by. "Excuse us. Excuse us please, passing through," they say as they carry the object between the professor and the student. It takes just a couple of seconds, but it's enough time for the switcheroo. The student—perhaps dressed in jeans and a red T-shirt, with dark hair—ducks behind the object and moves off. A second student who was crouching and moving behind the object—perhaps with blond hair and several inches shorter, dressed in slacks and a collared shirt—now stands up in his place. He is holding the map as he sidles up to the professor, who, amazingly, fails to recognize the change. Perhaps all students are the same in the professor's mind, but you still have to marvel at his change blindness. The experiment has been replicated many times, switching characteristics such as height, accent, and clothing of all kinds.

Miguel Angel Gea, the magician, figures that if you fail to notice two very different people swapping places, then you can miss just about anything. Certainly you can mistake one card

An absent-minded professor fails to notice when the student he's talking to trades places with a different student.





for another. One afternoon at the conference, he demonstrates how. Dressed in his usual casual attire, Gea calls for a volunteer from the audience. Once she is onstage, he asks her to pick a card from the deck. It is the eight of clubs. He shuffles it back into the deck. "I like to pull your card from my pocket," says Gea as he magically pulls the eight of clubs from his right hip pocket. Applause.

He looks at the volunteer. "Did you like that trick? Yes? There are tricks I don't like." He raises his empty hand toward her and reaches into her hair. As he pulls away, the eight of clubs is back in the palm of his hand. "Other magicians like to pull cards from people's hair. But I don't like that trick myself," says Gea. The audience snickers.

Next, Gea slides the eight of clubs back into the deck and places the deck on the table, holding a few cards out. He then rubs those few cards between the thumb and the fingertips of his right hand. "Other magicians prefer to make coins appear," he says, as a large coin slides out from between the rubbed cards to his left palm. The crowd responds with oohs and aahs.

The volunteer shakes her head in disbelief. He looks at her as he drops the remaining cards on the table—now a full deck that obviously includes the eight of clubs—leaving only the coin in his left hand. He tosses it into his right palm. "But me, no. I don't like tricks in which cards are taken from your hair, or even tricks with coins," he says as he tosses the coin back again—but this time it disappears.

"No," says Gea, "I prefer tricks with a single card in my pocket." He drops his empty right hand into his pocket and pulls out a card with its back to the audience. "And this single card is your card," he says as he rotates it forward to miraculously reveal the eight of clubs. Wild applause.

The Secret

Miguel Angel Gea has a sly smile on his face. He turns to the audience. "Would you like to know how that trick worked?" We shout a resounding "Yes!" He stands there for a second, as if contemplating his next move. He seems suddenly awkward. "It's a little difficult for a magician to reveal a trick," he says sheepishly. The audience laughs, sympathetically, as the magician reaches a decision. Flinging his arms over his head, he pronounces, "For science!" and launches into an explanation that fascinates scientists and artists alike.

He reveals that the trick starts before the show, when he picks two similar-looking cards, in this case the eight of clubs and the eight of spades. He places the club above the spade and puts the deck in his pocket for safekeeping until the show.

When Gea asks the volunteer to pick a card, he uses a *force* so that she chooses the eight of clubs without realizing it. *Forcing* refers to a number of methods used by magicians to make you think you are freely choosing a card when, in reality, you're taking exactly the card they want you to take.

When the volunteer puts the eight of clubs back into the deck, it is not randomly inserted. Gea again forces her to place it where he wants it—directly above the eight of spades. His subsequent moves are basic sleight of hand. He "shuffles" the deck so that the two black

You Are Bad at Multitasking. Yes, You.

Think you can talk on the phone while skateboarding? Listen to music while you write an English paper and watch a football game on TV? Send a text message, play a computer game, and watch a YouTube video while you have an argument with your little brother?

Think again. A decade of research clearly shows that multitasking—the ability to do several things at once, efficiently and well—is a myth. Your brain can't really follow two or three things at once. It is built to respond to just one thing at a time.

For example, research shows that you can't simultaneously give full attention to both the visual task of driving and the auditory task of listening, even if you use a hands-free device. In fact, people who talk on cell phones while driving a car have the same attentional focus as people who are legally drunk.* When you pay attention to the phone conversation, you "turn down the volume" on the visual parts of your brain, and vice versa.

Studies also show that people who are bombarded with several streams of electronic information do not pay attention, control their memory, or switch between topics as well as those who complete just one task at a time. Chronic multitaskers "are suckers for irrelevancy," says Stanford communications professor Clifford Nass. "Everything distracts them." They can't ignore things, can't remember as well, and have weaker self-control.

Another of our colleagues, Russ Poldrack at the University of California, Los Angeles, has shown that people use the *striatum*, a brain region involved in learning new skills, when they are distracted. But they use the *hippocampus*, a region involved in storing and recalling information, when they are not distracted. We may feel that multitasking is the same as doing tasks one at a time, but our brians can tell the difference. "We have to be aware that there is a cost to the way that our society is changing, that humans are not built to work this way," says Poldrack. "We're really built to focus. And when we force ourselves to multitask, we're driving ourselves to perhaps be less efficient in the long run even though it sometimes feels like we're being more efficient."

Magicians know that multitasking is an urban legend, so they use a "divide and conquer" approach with attention: they split your attention so you cannot concentrate fully on any part of the stage at a given time.

When your to-do list is many pages long, you may feel tempted to do two or more things simultaneously—for instance, studying your spelling words during band rehearsal. Chances are, you will do neither task well. For best performance, do one task at a time.

*The same problem does not happen when the driver talks to a passenger in the car, because both people will quiet down or stop talking when traffic gets heavy, it starts raining, or the driver needs to make a quick lane change. The passenger sees what the driver sees, whereas the person on the cell phone does not.

eights are on top. He palms them and drops both in his pocket. When he says, "I like to pull your card from my pocket," he reaches in for the eight of clubs and leaves the spade behind. (You can probably see where this is going.) He then works it so he "pulls" the eight of clubs from the volunteer's hair. He uses the coin routine to distract you from his main goal: change blindness.

When all the cards are on the table, you assume the eight of clubs is safely somewhere in the pile. That's when Gea reaches into his pocket and removes the eight of spades. He finishes his routine by saying, "No, I prefer tricks with a single card in my pocket," and he flips the eight of spades over. But you and everyone else are so eye-rollingly amazed, so completely enthralled by the fact that the magician has impossibly produced the eight of clubs from his pocket, when it's supposed to be on the table, that you fail to detect that it's not the eight of clubs at all. It's a spade.

Change blindness studies show that you will not notice dramatic changes in a visual scene if they occur during an interruption—such as a magician reaching behind the ear of a spectator, or two workmen carrying a door between you and the person you are talking to—even when you are looking right at the changes. Change blindness also lets us ignore common mistakes called *continuity errors* in movies. A character's hair may be in a ponytail in one scene and down in the next scene, for example. Chances are you'll miss it.

Slow or gradual changes are also very difficult to see, especially if we are not focusing our attention on the changing object. More research by Dan Simons has shown that whole buildings, boats, people, and other obvious objects may appear and disappear unnoticed, right in front of our eyes, if they do so slowly enough.

It's interesting to think about how many things in our lives may slowly change without our awareness. Our bodies gradually grow and change without our noticing anything different from day to day. Other aspects of our lives, schools, and friendships may similarly change, worsening or improving so gradually that we don't notice it.

The Greek philosopher Epicurus knew that we usually adjust to—and ignore—gradual improvements in our lives. He wrote: "Do not spoil what you have by desiring what you have not; but remember that what you now have was once among the things you only hoped for." It's wise advice, to which we might add: Watch out for gorillas.

Stephen L. Macknik, Susana Martinez-Conde, and Sandra Blakeslee are the authors of Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions. *Stephen and Susana are neuroscientists at the Barrow Neurological Institute in Phoenix, Arizona. Sandra Blakeslee is a writer in New Mexico.*