

**Review: *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Brains*
Stephen Macknik and Susana Martinez-Conde, with Sandra Blakeslee
London, UK: Profile Books, 2011, 291 pp.**

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Light strikes your retinas. Sound waves strike your eardrums. As you walk, something furry brushes your leg. Such impingements provide the information from which your perceptual systems infer the shape, distance, and surface properties of objects in your environment.

But that information does not uniquely specify what those objects are. Take vision. All the outside information you get comes via 2D patterns of retinal excitations. But any 2D pattern of excitations *could* be caused by indefinitely many possible external objects, which all would happen to have the same retinal projection from a certain vantage point. What's a visual system (or any perceptual system) to do?

The answer is simple: make assumptions. A 2D array of photon excitations doesn't *by itself* allow your visual system to infer the geometry of an object. But that array, *plus* the assumption that converging lines indicate distance, will get your visual system started. Now add this assumption: two straight edges with the same orientation on either side of an occlusion *connect* behind the occlusion. Add these and still other assumptions and expectations, and a visual system can start to infer a 3D world from 2D input.

Or as Stephen Macknik and Susana Martinez-Conde put it in their exciting new book *Sleights of Mind*, "The spooky truth is that your brain constructs reality, visual and otherwise" (p. 8).¹

From this it follows, as surely as day follows night, that to understand perceptual systems, we must understand the assumptions they make.

This is where *illusions* come in. Illusions capitalize on the assumptions your perceptual systems make by presenting situations that (i) trigger those assumptions and (ii) render those very assumptions false. For example, a picture with converging straight lines *appears* to have tracks that get farther and farther away, even though the canvas is flat. If a green splotch (seen as a cactus) occludes part of a track, that track is seen as continuous anyway.

Vision scientists have long studied illusions for this very reason. But for too long, an entire *genus* of illusion has been mostly ignored: magic tricks.²

So, first and foremost, we should be glad that Stephen Macknik and Susana Martinez-Conde, with help from Sandra Blakeslee, have written *Sleights of Mind*, which is dedicated to studying magical illusions to illuminate the psychology and neuroscience

¹ This goes also for at least hearing and touch. Does the same point apply for smell (not to mention taste)? I'm not sure whether anyone has a good answer to that question at this point in time. *We* can be deceived about what we're smelling by, say, artificial cherry flavoring. But does the olfactory system itself deliver a false representation of *actual* cherries? or simply an accurate indication of cherry scent? If it's the former, then the olfactory system must be making assumptions in some sense. If the latter, then not.

² I doubt a single reader of this journal will take this to suggest anything supernatural. But just to be clear, here it is: nothing in either *Sleights of Mind* or the present review is meant to suggest that "magic" involves real supernatural powers. The interest lies rather in the illusion thereof, which capitalizes on perfectly *natural* neuropsychological tendencies.

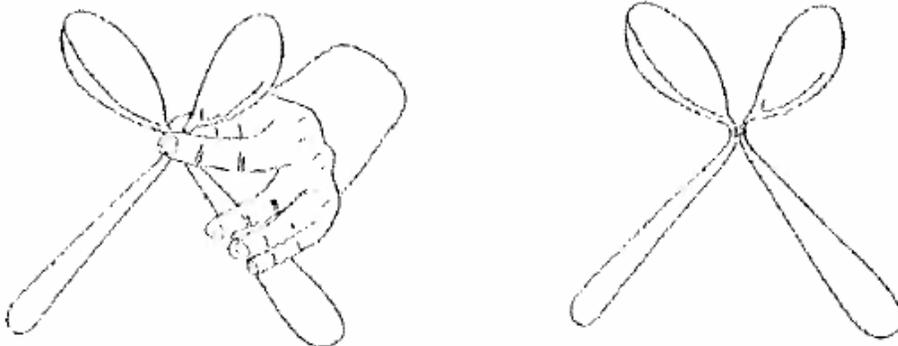
of perceptual systems. The rationale for the book is thus clear. Magicians are experts at illusions of all sorts—even illusions that science hasn't yet understood—so perceptual psychologists and neuroscientists *ought* to be interested in their work.

In what follows, I'd like to give a sense of the book's contribution by reviewing its treatment of two key examples. Then, I'll suggest how the book's approach could be relevant to a further important issue in cognitive science, namely, the evolutionary status of susceptibility to illusions. My aim in raising this further issue is not to criticize, but to say to others in the cognitive science community interested in these topics: "Onward!"

One brief *caveat*. The authors always give a "Spoiler Alert!" to warn the reader when they are about reveal the secrets behind a magic trick. I'll offer one too. DO NOT READ FURTHER, unless you're willing to learn the secrets behind telekinetic spoon bending and the "Miser's Dream" (where a magician pulls more than a dozen coins out of thin air).

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Magicians can make a spoon appear to bend before your eyes without physically manipulating the spoon in a way that would cause it to bend. Telekinesis? No. The secret behind the trick is that the spoons that appear to bend *were already bent in the first place*. The magician just held them in such a way that they appeared straight. Consider this pair of diagrams from page 36 of *Sleights of Mind*.



The left image represents what the magician presents to the audience. Behind the magician's finger, however, the spoons are bent. The audience looking at what's on the left *sees* two straight spoons that cross. As Macknik and Martinez-Conde explain, once the visual system has represented the spoons as straight, the audience is set up to be amazed by the sudden bending that appears when the magician moves his or her³ hands in the right way.

So the trick is in getting the visual system to see (or "construct") straight spoons in the first place. The visual system does this because of the *principle of good continuation*, which has as a sub-principle *amodal completion*, "the process by which an object that is occluded by a second object appears whole to you" (p. 37). Just like the

³ I'm a big fan of the gender-neutral "she"—i.e., using just "she" to mean *he or she*. It's a simple way to combat sexism. But, I must confess, it would feel a bit forced in this context, since it appears that *almost* all the magicians are men. Why is that? I don't know. And I'm not sure even Larry Summers could explain. For lack of a better option, I'll go with the somewhat inelegant "he or she." In any case, Susana Martinez-Conde herself has become a skilled amateur magician, so the "or she" part is not mere formality!

train tracks that continue behind the cactus, the spoon apparently continues behind the finger. (This trick reveals another point about attention and magic tricks: the actual manipulation is often not *when* the audience thinks it is.)

Let's now consider the "Miser's Dream":

Teller paces the stage. "Suppose I produce a coin." He holds his right hand high over his head and out of thin air produces a shiny silver coin. Then Teller drops the coin into a brass bucket held in his left hand. You hear a loud clink. He thrusts his right hand in a different direction and snatches another coin from the air. *Clink*. Then another . . . Teller spreads his hand and fingers wide so that you can see he is not hiding anything.

Then Teller walks up to the audience and, combing his fingers through a man's white hair, pulls out yet another coin and tosses it into the bucket. *Clink*. (pp. 190-191)

How does this work? Often when the right hand makes a throwing motion, the bucket-holding left hand (secretly hiding some coins) just drops one of its coins to make the clink. The right hand actually keeps the coin, which allows it to be apparently thrown over and over. But when audience members see the flash from the right and then hear the clink, they experience the toss of the coin into the bucket. This is a *multi-modal* illusion, since it requires more than one sense modality.

Macknick and Martinez-Conde appeal to the psychological weakness of *illusory correlation* to explain the Miser's Dream. The idea is straightforward: the mind often infers a single object or event as the causal source of two or more correlated events, especially when similar events have been correlated in the past. In this case, the flash of a coin and a clinking sound are almost always correlated with the actual trajectory of a coin from the flash location to the sound location. So the audience's history of flashes and clinks sets them up to be suckered by this perceptual correlation.

This is just a sample of two illusions and corresponding psychological principles discussed in *Sleights of Mind*. Anyone who found this interesting can look forward to more. Here are just a few of the further principles that Macknik and Martinez-Conde magically illuminate: after images, corollary discharge, occlusion, adaptation, habituation-dishabituation, attention's suppression of the peripheral, and the persistence of vision. The list could be much longer. Not sure what some of these are? You know what to do.

(Let me make a brief critical comment before moving on. The point about illusory correlation is basically correct; we must have some such tendency. But I worry that positing "illusory correlation" to explain a magic trick is a little like positing "dormitive powers" to explain why a sleeping pill makes you sleepy. Sure, something like that must exist. But have we explained anything? In my view, the book could have done more than it does to connect principles like "illusory correlation" to (i) larger bodies of psychological data and (ii) *more* neuroscientific data, which would have put more substance on the principles appealed to. To be clear, I wouldn't target this criticism at all or even most of the psychological phenomena appealed to in the book; see p. 40, for example, for a very nice discussion of the psychology and neuroscience behind good continuation.)

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Now for a further question. *Why* do these psychological phenomena—the ones that make us susceptible to illusions—exist? I think Macknick and Martinez-Conde are on the right track when they write:

To the generation that preceded us, illusions were considered errors of perception. The late Richard Gregory, the British psychologist who is widely known as one of the most

prolific perception scientists in the world, liked to say that illusions are where the visual system got it wrong.

We disagree. Illusions are not exceptions and they are not necessarily mistakes. . . . They are adaptive shortcuts that your brain makes to speed up such processing, or reduce the amount of processing necessary to provide you with the information you need to survive and thrive . . . (p. 251)

This is close, but it needs to be sharpened a bit. It's not the illusions themselves that are adaptive shortcuts. Rather, the *assumptions* the visual system makes, which have the possibility of illusion as a byproduct, are adaptive.

Let's briefly use Mother Nature as a metaphor for natural selection. Mother Nature *couldn't* have given us a visual system without giving us one that made assumptions. We would see nothing! And with assumptions come the possibility of illusions. So when choosing whether to give a visual or other perceptual system a particular assumption, Mother Nature must ask: (1) how much does it cost? and (2) how much does it pay? Good completion must actually pay quite well. I can grab a rabbit in a bush even when I only see the tail. Or I can start running the very instant I see a lion's tail popping up out of the grass. That's because I saw a rabbit, and I saw a lion. The cost isn't so bad—a few “illusions” here and there. The same point goes through, *mutatis mutandis*, for many of the other psychological tendencies discussed in *Sleights of Mind*.

Many of the present readers will have been taught to dismiss the previous paragraph out of hand as shameless evolutionary speculation. But the point is not that my particular suggestions about the evolutionary costs and benefits of good completion are correct. It's that the structure of our thinking about the etiology of illusions needs to be cognizant of the balancing act involved in the design of a perceptual system. It is tempting on a superficial consideration of many human cognitive foibles to conclude, “Well, I guess humans just aren't that smart!” And with some illusions, the visual system may have just “got it wrong.” But the more interesting illusions result from evolutionary trade-offs. Assumptions are a must, but illusion is their byproduct.⁴

My present hope is just that you'll ponder this, as you enjoy *Sleights of Mind*.

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⁴ There is another issue in psychological theory that the illusions in *Sleights of Mind* raise that I don't have space to discuss, although it's important. Jerry Fodor's *Modularity of Mind* (1983, Cambridge: MIT Press) famously advocates that “input systems” (like vision) are modular. On Fodor's conception of modularity, this means they have at least two properties. First, they are informationally encapsulated. Second, they are “hard-wired.” But the two illusions I discuss here problematize both of those properties. If the visual system is encapsulated, at what level of processing does the *clink* sound in the Miser's Dream cause the (apparently perceptual) illusion that a coin was just thrown? More generally, multi-modal illusions as a class are a problem for the advocate of informational encapsulation. And if the visual system is innately hard-wired, how does it “know” (in whatever sense) the shape of the spoon—information it only could have acquired from the environment?