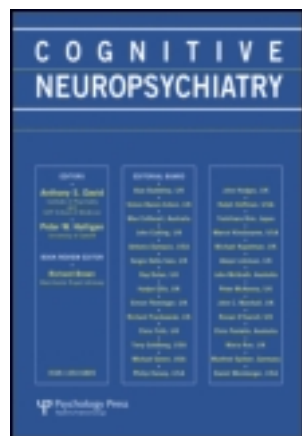


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On: 06 October 2011, At: 15:44

Publisher: Psychology Press

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Cognitive Neuropsychiatry

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/pcnp20>

Author Response

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Available online: 08 Sep 2011

To cite this article: Stephen L. Macknik & Susana Martinez-Conde (2011): Author Response, *Cognitive Neuropsychiatry*, 16:5, 479-480

To link to this article: <http://dx.doi.org/10.1080/13546805.2011.598058>

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Book Review

Macknik, S., & Martinez-Conde, S., with Blakeslee, S. (2011). *Sleights of mind: What the neuroscience of magic reveals about our brains*. London, UK: Profile Books. pp. 291. ISBN 10846683890. £12.99

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 two-dimensional (2-D) patterns of retinal excitations. But any 2-D 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 2-D 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 three-dimensional (3-D) world from 2-D 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 capitalise on the assumptions your perceptual systems make by presenting situations that (1) trigger

¹This 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 flavouring. 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.

those assumptions and (2) render those very assumptions false. For example, a picture with converging straight lines *appears* to have tracks that get further and further 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 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.

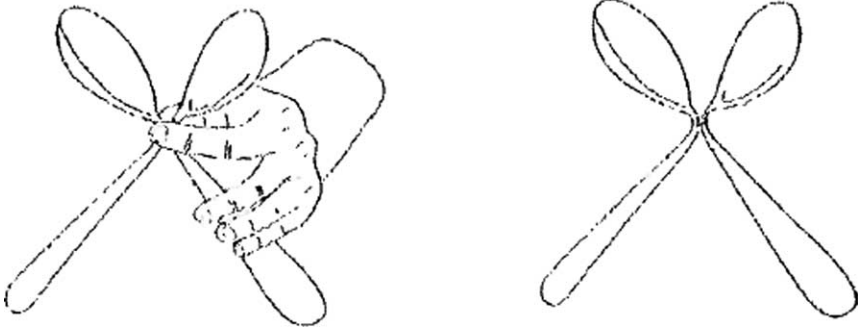
In what follows, I'd like to give a sense of the book's contribution by reviewing its treatment of two key examples. Then, I'll suggest how the book's approach could be relevant to a further important issue in cognitive science, namely, the evolutionary status of susceptibility to illusions. My aim in raising this further issue is not to criticise, 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).

* * *

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*.

²I 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 capitalises on perfectly *natural* neuropsychological tendencies.



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 subprinciple *amodal completion*, “the process by which an object that is occluded by a second object appears whole to you” (p. 37). Just like the 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)

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!

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 *multimodal* illusion, since it requires more than one sense modality.

Macknik 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: afterimages, 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 (1) larger bodies of psychological data and (2) *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.)

* * *

Now for a further question. *Why* do these psychological phenomena—the ones that make us susceptible to illusions—exist? I think Macknik 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 aetiology of illusions needs to be cognisant 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 tradeoffs. Assumptions are a must, but illusion is their byproduct.⁴

⁴There 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. Fodor (1983) 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 problematise 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, multimodal 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 could only have acquired from the environment?

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

Fodor, J. (1983). *Modularity of mind*. Cambridge, MA: MIT Press.

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Author Response

We're very grateful to Neil Van Leeuwen for his very kind words about our new book, *Sleights of Mind: What the Neuroscience of Magic Reveals About Our Brains* (<http://sleightsofmind.com>). Because Van Leeuwen has only one significant concern, we will focus on that point.

We suggested in *Sleights of Mind* that sensory and cognitive illusions are not really errors in perception so much as achievements of perception. In this sense, we disagree with the previous generation of illusion researchers. Whereas they believed that illusions are the inevitable mistakes the brain makes while doing the difficult job of reconstructing reality in our brains, we believe that the brain takes shortcuts, and often outright confabulates, much of what we experience because it is faster and easier than reconstructing the world accurately. It follows that our conscious experience is not a reconstruction of reality at all, but merely a thin and often inaccurate simulation of reality based on very little real data from the outside. Our bodies in this scenario are no more than meat robots that we drive around in order to feed bits of information to our brains—in addition to, well, *food*. It doesn't much matter that what we perceive is inaccurate so long as we and our progeny survive to perceive it again in the future. We assert that illusions are adaptive because they save time and computational resources as compared to what the brain would have to do to actually reconstruct reality in any sort of accurate way.

Van Leeuwen resonated with our assertion and took it one step further. He suggests that what this means is that the brain, as the result of a long evolutionary process, has become an assumption machine. All illusions are basically in service to the assumptions the brain makes about the real world outside. Therefore, he postulates, it is the assumptions themselves that are adaptive, and illusions are the byproduct of those assumptions.

Van Leeuwen provides a few examples in support of his idea: In amodal completion, in which our mind's eye fills in the hidden portion of a partially occluded shape, our brain makes an assumption about the missing portion of the object. There are also a number of magic effects in which the magician tricks the audience into making a specific assumption, only to show that it was wrong. Thus, the neural correlates of assumptions are an interesting issue both in magic and in life. We specifically state as much in *Sleights of Mind*.

But that's as far as it goes, because not all illusions are based on assumptions. At least, not in the sense that Van Leeuwen describes. For example, with edge contrast enhancement and other illusions based on lateral inhibition, our sensory systems enhance the spatial and temporal edges (the turning on and off) of stimuli, without inherent assumptions. The sensory systems thus introduce and process an inaccuracy because it enhances the detection of the stimulus, despite the fact that it renders it inaccurate. It's an adaptive system, yes, but not one based on an assumption.

We are immensely grateful to Van Leeuwen for his insightful comments about *Sleights of Mind*, but the words of a famous psychiatrist come to mind when we consider the idea that all illusions are based on assumptions: "Sometimes, a cigar is just a cigar." Illusions are often adaptive, but only some of them are based on assumptions.

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