http://www.newyorker.com/online/blogs/newsdesk/2012/12/what-neuroscience-really-teaches-us-and-what-it-doesnt.html?mbid=gnep&google_editors_picks=true#commentAnchor_nyr_2000000002063619

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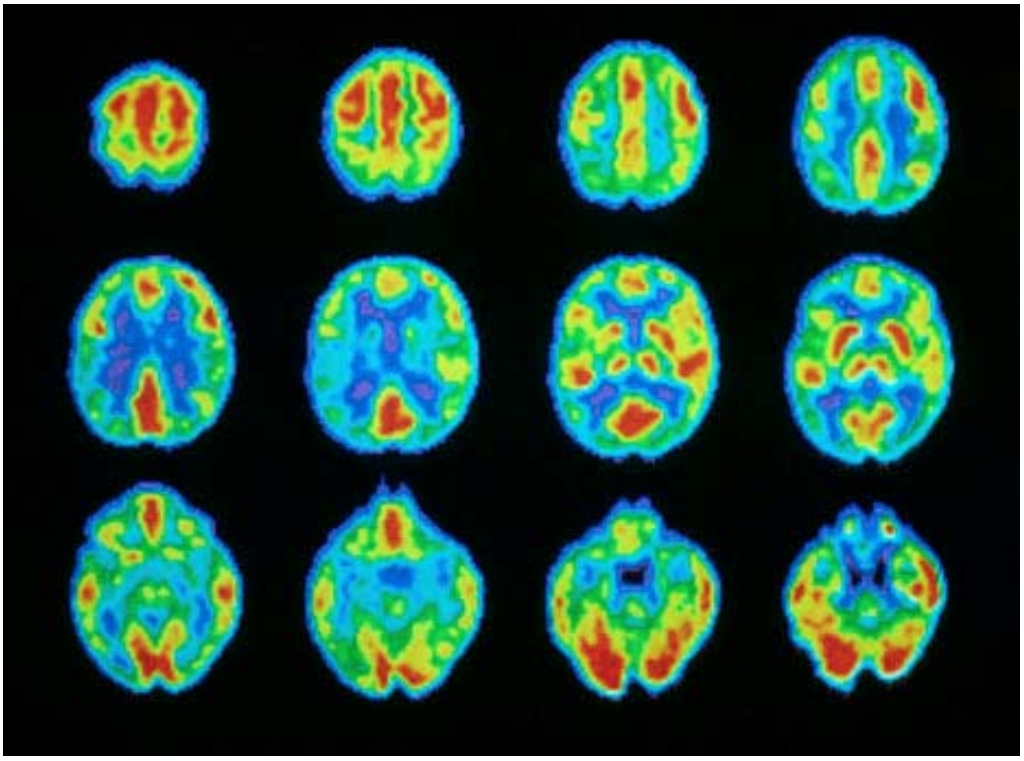
NEUROSCIENCE FICTION

Posted by *Gary Marcus*



In the early nineteen-nineties, David Poeppel, then a graduate student at M.I.T. (and a classmate of mine)—discovered an astonishing thing. He was studying the neurophysiological basis of speech perception, and a new technique had just come into vogue, called positron emission tomography (PET). About half a dozen PET studies of speech perception had been published, all in top journals, and David tried to synthesize them, essentially by comparing which parts of the brain were said to be active during the processing of speech in each of the studies. What he found, shockingly, was that there was virtually no agreement. Every new study had published

with great fanfare, but collectively they were so inconsistent they seemed to add up to nothing. It was like six different witnesses describing a crime in six different ways.

This was terrible news for neuroscience—if six studies led to six different answers, why should anybody believe anything that neuroscientists had to say? Much hand-wringing followed. Was it because PET, which involves injecting a radioactive tracer into the brain, was unreliable? Were the studies themselves somehow sloppy? Nobody seemed to know.

And then, surprisingly, the field prospered. Brain imaging became more, not less, popular. The technique of PET was replaced with the more flexible technique of functional magnetic resonance imaging (fMRI), which allowed scientists to study people's brains without the use of the risky radioactive tracers, and to conduct longer studies that collected more data and yielded more reliable results. Experimental methods gradually become more careful. As fMRI machines become more widely available, and methods became more standardized and refined, researchers finally started to find a degree of consensus between labs.

Meanwhile, neuroscience started to go public, in a big way. Fancy color pictures of brains in action became a fixture in media accounts of the human mind and lulled people into a false sense of comprehension. (In a feature for the magazine titled "Duped," Margaret Talbot described research at Yale that showed that inserting neurotalk into a papers made them more convincing.) Brain imaging, which was scarcely on the public's radar in 1990, became the most prestigious way of understanding human mental life. The prefix "neuro" showed up everywhere: neurolaw, neuroeconomics, neuropolitics. Neuroethicists wondered about whether you could alter someone's prison sentence based on the size of their neocortex.

And then, boom! After two decades of almost complete dominance, a few bright souls started speaking up, asking: Are all these brain studies really telling us much as we think they are? A terrific but unheralded book published last year, "Neuromania," worried about our growing obsession with brain imaging. A second book, by Raymond Tallis, published this year, invoked the same term and made similar arguments. In the book "Out of our Heads," the philosopher Alva Noë wrote, "It is easy to overlook the fact that images… made by fMRI and PET are not actually pictures of the brain in action." Instead, brain images are elaborate reconstructions that depend on complex mathematical assumptions that can, as one study earlier this year showed, sometimes yield slightly different results when analyzed on different types of computers.

Last week, worries like these, and those of thoughtful blogs like Neuroskeptic and The Neurocritic, finally hit the mainstream, in the form of a blunt New York *Times* op-ed, in which the journalist Alissa Quart declared, "I applaud the backlash against what is sometimes called

brain porn, which raises important questions about this reductionist, sloppy thinking and our willingness to accept seemingly neuroscientific explanations for, well, nearly everything."

Quart and the growing chorus of neuro-critics are half right: our early-twenty-first-century world truly is filled with brain porn, with sloppy reductionist thinking and an unseemly lust for neuroscientific explanations. But the right solution is not to abandon neuroscience altogether, it's to better understand what neuroscience can and cannot tell us, and why.

The first and foremost reason why we shouldn't simply disown neuroscience altogether is an obvious one: if we want to understand our minds, from which all of human nature springs, we must come to grips with the brain's biology. The second is that neuroscience has already told us lot, just not the sort of things we may think it has. What gets play in the daily newspaper is usually a study that shows some modest correlation between a sexy aspect of human behavior, with headlines like "FEMALE BRAIN MAPPED IN 3D DURING ORGASM" and "THIS IS YOUR BRAIN ON POKER"

But a lot of those reports are based on a false premise: that neural tissue that lights up most in the brain is the only tissue involved in some cognitive function. The brain, though, rarely works that way. Most of the interesting things that the brain does involve many different pieces of tissue working together. Saying that emotion is in the amygdala, or that decision-making is the prefrontal cortex, is at best a shorthand, and a misleading one at that. Different emotions, for example, rely on different combinations of neural substrates. The act of comprehending a sentence likely involves Broca's area (the language-related spot on the left side of the brain that they may have told you about in college), but it also draws on the parts of the brain in the temporal lobe that analyze acoustic signals, and part of sensorimotor cortex and the basal ganglia become active as well. (In congenitally blind people, some of the visual cortex also plays a role.) It's not one spot, it's many, some of which may be less active but still vital, and what really matters is how vast networks of neural tissue work together.

The smallest element of a brain image that an fMRI can pick out is something called a voxel. But voxels are much larger than neurons, and, in the long run, the best way to understand the brain is probably not by asking which particular voxels are most active in a given process. It will instead come from asking how the many neurons work together within those voxels. And for that, fMRI may turn not out not to be the best technique, despite its current convenience. It may ultimately serve instead as the magnifying glass that leads us to the microscope we really need. If most of the action in the brain lies at the level of neurons rather than voxels or brain regions (which themselves often contain hundreds or thousands of voxels), we may need new methods,

like optogenetics or automated, robotically guided tools for studying individual neurons; my own best guess is that we will need many more insights from animal brains before we can fully grasp what happens in human brains. Scientists are also still struggling to construct theories about how arrays of individual neurons relate complex behaviors, even in principle. Neuroscience has yet find its Newton, let alone its Einstein.

But that's no excuse for giving up. When Darwin wrote "The Origin of Species," nobody knew what DNA was for, and nobody imagined that we would eventually be sequencing it.

The real problem with neuroscience today isn't with the science—though plenty of methodological challenges still remain—it's with the expectations. The brain is an incredibly complex ensemble, with billions of neurons coming into—and out of—play at any given moment. There will eventually be neuroscientific explanations for much of what we do; but those explanations will turn out to be incredibly complicated. For now, our ability to understand how all those parts relate is quite limited, sort of like trying to understand the political dynamics of Ohio from an airplane window above Cleveland.

Which may be why the best neuroscientists today may be among those who get the fewest headlines, like researchers studying the complex dynamics that enter into understanding a single word. As Poeppel says, what we need now is "the meticulous dissection of some elementary brain functions, not ambitious but vague notions like brain-based aesthetics, when we still don't understand how the brain recognizes something as basic as a straight line."

The sort of short, simple explanations of complex brain functions that often make for good headlines rarely turn out to be true. But that doesn't mean that there aren't explanations to be had, it just means that evolution didn't evolve our brains to be easily understood.

Gary Marcus, a professor of psychology at N.Y.U. and the author of "Guitar Zero: The Science of Becoming Musical At Any Age", has written for newyorker.com about moral machines, Ray Kurzweil's new book, and deep learning.

Photograph by Roger Ressmeyer/Corbis.

Read more: http://www.newyorker.com/online/blogs/newsdesk/2012/12/what-neuroscience-really-teaches-us-and-what-it-doesnt.html#ixzz2E1gTOvVS

As a neuroscientist, I think it is unfortunate that Dr. Marcus has the opportunity to communicate science to a broad audience and has squandered it. Like any field (including developmental psychology), there is good science and bad science, and most of it is poorly communicated to the media. What is bothersome is that Marcus, along with other journalists, have been so uncritical about neuroscience criticism. Blogs like "neuroskeptic" are not particularly thoughtful or insightful, and many of the ideas in these blogs are half baked. Unfortunately, the people who write blogs don't have to deal with the same level of peer review that real scientists face, which is why we need journalists to be measured, not "neuroskeptics". That is, you should be just as skeptical of people making big claims about their data as you should of people who try to write off scientific conclusions with a soundbite. There is a lot of uncertainty in science. Deal with it.
Posted 12/3/2012, 2:59:03pm by memorist

The main problem with this article is that it assumes neuroimaging is all there is to neuroscience. The main problem is that deeper, more specific investigation of individual neuronal functions and communication pathways cannot technically or ethically be done in humans. Those procedures, for now, are allowed in lab animals and brain imaging studies--while they cannot provide that kind of detailed understanding--do at least give us a safe way to see if the same brain regions are involved in the human brain. And they do show how similar human and other animal brains are. Which offers some purpose to the suffering and sacrifice of tens of million of lab animals and raises another huge ethical question.
Posted 12/3/2012, 10:19:28am by megolmert

Ezra, Thank you for your comment with which I very much agree. My (1) was, of course, not in reference to yours which arrived while writing mine.
Posted 12/3/2012, 8:08:39am by cwk

(1) Why such lack of civility. Be glad that Jonah Lehrer is behind us. (2) And as Panksepp wrote in the Preface of his recent work: 'Still the new evidence obtained with those spectacular human brain-imaging technologies has clarified much about the cognitive aspects of emotion but rather little about the sources of such feelings in the brain.'
Posted 12/3/2012, 8:06:24am by cwk

If we want to understand human behavior, we need to study human behavior. What is in a brain is a product, not a cause.
Posted 12/3/2012, 7:59:37am by Ezra

have watched Dr. Daniel Amen on PBS lecture on controling the brain and been fascinated.....
http://www.skepdic.com/amen.html
Posted 12/2/2012, 6:29:22pm by robslocum

C_OLIVETREE's comment works for me. I watch several "daily digest" websites and see very regular inaccurate, overly interpretive reporting on new research vs. what is said in the abstract of the actual papers. Lay reporters often assert useful upshots to the research that are nowhere to be found in the journal-published pieces. They often misstate the significance of the new discoveries as potential "grails" leading to pharmaceutical or behavioral treatments. The research papers themselves are useful to other professionals who have sufficient understanding to interpret and utilize the data effectively. But the lay journalist's interpretation is too often very obviously driven by his profit motive.
Posted 12/2/2012, 3:51:52pm by naughtmoses

Did anyone edit this article?
Posted 12/2/2012, 3:27:43pm by alexannedra

I have been concerned with how brain science is used to support reactionary social norms. The notion that children and youth do not have a "fully developed prefrontal cortex" is regularly invoked to deny them rights on the basis that they are somehow incapable of making any decisions -- this applies to everything from extremely high insurance rates, to regular locker checks at public schools, to punitive age of consent laws. This follows after a lengthy period in history where scientific-sounding books and articles posited that non-Caucasians were inferior, that men and women had "different brains" that prohibited the latter from attaining the same status as the former, etc. Science is an important tool and with that importance comes a necessity to be careful with it, and not abuse it.
Posted 12/2/2012, 3:14:08pm by LiamCDG

@Caroline was the article's last paragraph really that hard to grasp? Marcus IS critiquing the pop-science journos, and he's not bashing neuroscience or saying we should give up on it (he explicitly says the opposite)—he's just saying that the field is made out to be more advanced than it truly is.
Posted 12/2/2012, 1:36:44pm by DavCat

Really, Caroline, this article was "stupid"? It contained no information and provoked no further thought on the subject at hand? Or is that words like "insufficient" or "I disagree" just aren't dramatic enough for you?
Posted 12/2/2012, 12:44:22pm by Kenji1

Would TNY pay an economics professor to write an article asking, "Should we give up on studying economics?" based on the observation that there are shelves full of popular get-rich-quick books on the market? What a stupid, fatuous article this is. I agree with C_olivetree that Marcus should have written more thoughtfully. But to do so, he would have had to critique pop-science journalists instead of neuroscience itself--and an article on that topic probably wouldn't entice as many readers to click through. Sheesh. Physician Marcus, heal thyself.
Posted 12/2/2012, 10:54:11am by Caroline49

My impression as a psychologist is that the true experts in the field of neuroimaging are acutely aware of the limitations of the techniques they use, which is clear from research published in scientific journals of high quality. However, when these same journal articles - must be said, highly complex and full of neuro-jargon - get into the the hands of lay, sensationalist journalists who oftentimes cannot even grasp the most basic foundations of experimental research such as 'correlation is not causation', that is where the problems and gross misinterpretations arise. That is when we read headlines such as those mentioned by the author, Gary Marcus. By the way, I would like to draw his attention to the work of Nora Volkow, now director of the National Institute of Drug Abuse (NIDA), on cocaine and D2 dopamine receptors. Clearly, even to lay viewers, affected brain areas do not always show up as jumbled blotches that tell 'six stories in six different ways'. Including some positive examples of how much we have already learned from neuroscience and neuroimaging, despite their limitations, would have been much appreciated.

Posted 12/2/2012, 8:52:34am by C_Olivetree