

BRAIN SCIENCE PODCAST

With Ginger Campbell, MD

Episode #23

Interview with Sandra Blakeslee, Author of *The Body Has a Mind of Its Own: How Body Maps Help You Do (Almost) Everything Better*

Aired October 19, 2007

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INTRODUCTION

This is the *Brain Science Podcast* – the podcast for everyone who has a brain – and I’m your host, Dr. Ginger Campbell. On the *Brain Science Podcast* we explore how recent discoveries in neuroscience are unraveling the mysteries of how our brains make us who we are. For more information including Show Notes, links to previous episodes, and information about how to subscribe, please go to the website brainsciencepodcast.com. We also have a Discussion Forum at brainscienceforum.com, and you can send me email at docartemis@gmail.com.

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Welcome back to *Brain Science Podcast*. This is [Episode 23](#). Today I have an interview with one of the authors of the book, [The Body Has a Mind of Its Own: How Body Maps Help You Do \(Almost\) Everything Better](#). We discussed this book back in [Episode 21](#), and today I’m interviewing Sandra Blakeslee. If you’re new to the show you don’t have to listen to [Episode 21](#) before you listen to this interview, but hopefully you will want to go back and listen to all of the old episodes when you get done.

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INTERVIEW

GC: Today on the *Brain Science Podcast* I have Sandy Blakeslee, author of *The Body Has a Mind of Its Own*. Sandy, I want to welcome you to the *Brain Science Podcast*.

SB: Thank you.

GC: I really appreciate your taking the time to talk with me today. I thought I might start out by asking you just to tell us a little bit about yourself.

SB: OK. Well, I'm a science writer. I've spent most of my career at *The New York Times*. I have kind of an odd family story. My grandfather was probably the first science writer in the United States back in the 20's. And my dad was a science editor at the *Associated Press*. I sort of fell into it quite by accident in the late 60's at *The New York Times*.

I won't bore you with the whole story, but I just loved it. I couldn't believe that you got paid to do this. You pinch yourself because it's so much fun. And my son trained as a neuroscientist, and then about six or seven years ago he started science writing too. So, I cover all sciences, but in the last 10 or 15 years I've specialized in neuroscience.

GC: And you've written several other neuroscience books before this one.

SB: Correct. I wrote, *On Intelligence*, with Jeff Hawkins, which is a phenomenally important book. He's giving the keynote at the Society for Neuroscience this year. Jeff, for the people who don't know, is the inventor of the Palm Pilot. And he's figured out how the brain works in terms of its cortical architecture, and he's building it in silicone right now—six-layer silicone. So, that's very cool.

And then I wrote *Phantoms in the Brain* with Rama—V.S. Ramachandran—about 10 years ago. That's about phantom limbs and all sorts of other mysteries of the brain. And that book is used widely in introductory neuroscience courses.

I was just back at MIT last week—I was giving a talk there—and about half a dozen students came up to me and said that they got interested in neuroscience because of that book. Which is very gratifying. And Rama is such a character, and absolutely brilliant and a lot of fun to work with. And then I've written a bunch of books on divorce and children of divorce.

GC: I haven't had a chance to read Rama's book yet, but I've had a lot of listeners ask me to get him on the show. Maybe I'll have to talk to you later about how I can reach him. *On Intelligence* actually is kind of what got me into doing this podcast, because I did a very short review of it for another podcast last summer. And then I realized there's so much material here, I'll never run out of material. And so, I really owe the *Brain Science Podcast*, to *On Intelligence*, I guess.

SB: Oh, that's great.

GC: In fact I didn't realize until today when I was looking you up again, that was another reason why I had your name on my mind as an author of books I had read.

SB: Yes. Well, there's a funny story. When we finished *On Intelligence*, which was about three years ago, Jeff came to the Society for Neuroscience—which has

got 30,000 people; it's just an enormous meeting—and he was sort of wandering around quite lost. He knew quite a few people in neuroscience because he started an institute called [The Redwood Neuroscience Institute](#). But it was pretty small, and by invitation, and so he was not a known figure.

And he really was a little uncomfortable. And I was standing there and I said, 'Well, you know, Jeff, probably in five to ten years you'll be invited back to this meeting and you'll be asked to give the big plenary address.' And he called me recently and said, 'Guess what? It's only taken three years.' And so, it's very exciting.

I don't have all the details right now of where they stand with this company. It's called [Numenta](#), and they're building in silico this cortical architecture that he figured out from the human brain, putting it into silicone. And it's potentially going to be a major breakthrough for machine intelligence.

GC: Yes, I'd love to talk to him. I've sent him a few emails but I don't think they've gotten past the spam filters yet. [Note: Jeff Hawkins was later interviewed in [Episode 38](#).]

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At this point I have to break into the interview to apologize for the fact that the sound is so bad. I wish I had the skill to get the underlying noise out of this audio, but I don't. So, all I can do is apologize. And I promise that I'm going to be working on improving this problem for the next episode.

Meanwhile, getting back to the episode, I asked Sandy to tell me a little bit about her co-author, who was her son, Matthew.

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SB: Well, Matt also helped with *On Intelligence*. He was freelancing and he was sort of sitting there with some time on his hands. And I said, ‘How would you like to help write a little bit of this book?’ He wasn’t on the cover—you know, he was not an author of the book—but he actually wrote some of the most beautiful sections; because he is a neuroscientist by training and he’s just a beautiful writer.

So, when I got the idea for this book I wanted to have another person to bounce the ideas off of. And I couldn’t do this book with a scientist, because we cover so much material using this idea of body maps—we cover really a lot of neuroscience—and I think a particular neuroscientist would have been wedded to his or her own particular area. And so, I asked Matt if he’d be available.

And we wrote the proposal together, and we wrote the book. We thought it would take one year. It took us two years. And it’s been a pleasure writing together. We’re thinking of maybe doing another one. If this one is successful we might do another.

GC: Well, you answered my next question which was going to be to tell me the story of how this book happened. So, you answered that one. So, you talked to a lot of different scientists in doing the research for *The Body Has a Mind of Its Own*, didn’t you?

SB: Oh, absolutely. In fact we’ve gotten a few requests from readers saying, ‘Why don’t you have the sources down on your website?’ And Matt and I talked about that. But I have in one side room of this house about 10 boxes full of papers that I carefully read, I’ve got 30 or 40 books that I read, and I’ve got all these interviews that we did. So, I’ve told people that I would put some stuff up on the website for sources, but we covered a huge amount of material so I need to narrow it down.

But that's what you do as a science writer. I mean I've done this my whole life, and I describe it sometimes like being a baleen whale. You sort of navigate your way through an area of interest and you suck it all in. You bring in all this information—hundreds of times more than you could ever use—and then you have to organize it, and put it into a narrative, and decide how you want to tell the story.

And you leave out about 95% of what you know for everything you write as a science writer. Every time I do an article for *The New York Times* I'm leaving out at least 90% of what I know. That's just the way it is. That's the trick of science writing, is to take all that information and then to throw out what's sort of ancillary and is not carrying your message or your story. Does that make sense?

GC: Absolutely. I certainly appreciate what you're talking about. Because in putting together this podcast, when I try to give a discussion of a book—which I don't really consider to be a book review, I'm more trying to get the main ideas across to my audience—I have to do the same thing. I have to leave so much stuff out and decide which stuff to leave in.

SB: Right. Exactly.

GC: It's another layer filtering beyond the one that you already did. And I realized when I was making Show Notes on my website for your book and trying to list all the scientists you talked to, even in my attempt to do that I left a bunch of them out.

SB: I promise people that are interested in this that I will put it up on the website. I may not get to it until I get back from San Diego, but Matt and I need to go through the book and just pull out key references. Because we've gotten queries, and we write back to people when they ask us. So, if anybody has a

specific question I'm happy to answer it. But we will put something up on the website about that.

GC: Well, I'll look forward to that. And I'll link to it when it gets up on there. I already have links to your website.

SB: I want to tell you how I got the idea for the book. Can I do that?

GC: OK. Sure.

SB: This is very relevant to talking about the Neuroscience meeting. It was about I guess the year 2000, and I was at the meeting. This is a huge event, and there's row after row after row of posters. And what I like to do is just cruise the posters—you know go down aisle after aisle and with almost peripheral vision look for things that might pop out.

And there was a paper by an Italian neuroscientist that talked about peripersonal space; which I had never heard of. And so, I went over and I started asking him. And we were talking about strokes and this method he had of studying strokes. But then I said to him, 'Well, what's peripersonal space?'

And it was so cute. He sort of stepped back and took a pen, and he said, 'You see this pen? It is now outside of your peripersonal space.' And then he started moving it closer and closer to me, and then he got it into the area around my space—which is if you put your arms out, and over your head, and to your side, and down by your hips, that's your peripersonal space. And he was telling me that that space is actually literally mapped in your parietal lobe.

And I couldn't believe it. Because I knew that the brain maps the body. I knew about the Penfield Maps, and the classic touch maps, and the classic motor maps. But the idea that the space was mapped was new to me. And then that when you

use tools the receptive fields for the maps increase in size—which I can explain—it was just enchanting.

And then a bunch more findings were coming along around that same time about tool use and mapping; and about mirror neurons, which is about mapping your social world; and then this whole thing about interoception, which is how you map the internal feelings from your body. I mean this was just so exciting, that that's what Matt and I did. And about two years ago we just sat down and wrote out all of the chapters that we could do, and then wrote it. But we got a chance to travel all over and talk to a lot of people.

GC: Was there any scientist that really made a big impression on you?

SB: Let me think about that for a second. Well, it was in each field. Like in the mirror neuron world I knew Marco Iacoboni at UCLA, who is wonderful. He has been doing a lot of the seminal work in that. And this guy, Rizzolatti—he's in Italy, and I knew him. [Note: for more on mirror neurons listen to [Episode 35](#) and [Episode 39](#).]

So, we argued that you map tools, but that the joystick that you use to play video games—or, particularly in virtual reality—is captivating these body maps in your parietal lobe in a very active sense. So, Matt flew over to Japan and spent some time with this guy, Iriki, who is doing this pioneering work in looking at how the parietal lobe is mapped in cyberspace. So, that was very cool.

And then for vestibular work, I called up Jim Lackner at Brandeis, who is Mr. Vestibular. For each section there were key people. There's a guy named Bud Craig who is absolutely one of my heroes in neuroscience. He's at the [Barrow Neurological Institute](#) in Phoenix. And I guess he's a geek, in a way. But he's a neuroanatomist, and he's been tracing out these pathways of how the brain reads

the body's state, in sort of the classical sense that was posited over a hundred years ago by William James.

And this network that Bud has found is so important for understanding alternative medicine like acupuncture and meditation, and why these modalities work on things like chronic pain, and anxiety, and addictive states, and things like that. He's really on to the molecular mechanisms, or the reductionist mechanisms, for why those things work. So, I think he's one of the most important people in the book.

GC: That did come through in your writing. For some reason his name really stuck in my mind.

SB: Well, that's good. Because people still don't know about him that much. I mean he's getting more recognition. But he's very quiet. He's not a self-promoter. He's not a guy that says, 'Look at me, look at me.' He puts out these papers that are very hard to read. You have to read them about five times before you can really follow them. And then when you do, they're just astonishing.

GC: So, he writes like an engineer?

SB: Yes. He writes like an engineer, and he refuses to translate any of the terms, and they're a lot of work to read. They're not easy. But when you do, when you just spend a lot of time following them through, what he's arguing is incredibly important. I'm basically a layperson, but the people that I respect in the field, like Pat Churchland¹, John Allman, and people like that, have read his work and think it's sensational.

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¹ Patricia Churchland was interviewed in [Episode 55](#).

GC: We could probably talk forever about the scientists, but let's talk some more about your book. Obviously when I was talking about your book a few weeks ago on my show I could barely scratch the surface of all the fascinating material that it contains. So, I was hoping that we might be able to talk about a few of the ideas I didn't have time to discuss. And I wanted to ask you some questions that have come from my listeners.

SB: OK, great. Let's do it. That sounds good.

GC: First of all, I really appreciate the fact that you took time to actually listen to the podcast, so I wanted to give you a chance to tell me if there was something important that you think I left out.

SB: Well, I listened to it a few days ago, but I was amazed at how thorough you were. You really covered it. It was amazing, because the print reviews normally are very cursory, and you went through it in a very detailed way. There was nothing inaccurate. You were very faithful to the material. And I've actually sent that out to a number of friends so if they want to get a précis of the whole thing, it's all there. So, I don't know what you left out. You'd have to sort of tell me.

GC: OK. Well, I think it will come out in the questions that I got from my listeners, because they seemed to hit what I thought were the gaps. One of my listeners is a lady named Kate. She lives in Cardiff, Wales, and works in a research lab.

She wanted you to talk some more about out-of-body experiences. I'm going to quote from her email. She said, "I had one of these once when I was quite ill and I was wondering how can this"—the body maps, I assume she means—"explain the feeling you have of looking down on your own body?" She asked, "Has anyone done any work on this sort of stuff?"

SB: Oh, absolutely. Yes. And that's such a cool question. There are a couple of people—again, these people are in Europe. There's this guy named Olaf Blanke in Switzerland, and a few years ago he had a report of some patients that he had. He's a neurologist and he does this sort of classic open brain exploratory technique that you do before you do epilepsy surgery.

You open up the skull and you have the brain surface exposed, and you take an electrode and you start stimulating little points, because you're looking for the locus of the abnormal tissue. So, you're mapping the brain, and you want to make sure you're sparing language areas or anything that's really important. So, you're looking for where vision is, where language is, things like that.

And he was doing this one day to this woman, and he hit this one spot and then she said, 'Yikes,' and she was floating on the ceiling looking down at him. He turned off the electrode, she was back in her body. He turned on the electrode—which was silent, so she couldn't correlate it with sound—and she was out of her body again, and then back; in and out, in and out. And she was describing this sort of ghostly sense of floating on the ceiling. And some of this is in the book.

So, he thought that was amazing, so he tried it on other patients and found the same thing. The region that he stimulated is called the right angular gyrus. If you put your hand above your ear it's where the temporal and parietal lobes come together, and this is an area that maps your body in space. It's a big area and it does other things than just that, but it's one of the nodes of your embodiment in space. And by hitting it he was able to dissociate the map.

Then he had another patient where he was exploring the left side of her brain, and he was doing the same thing with the electrode. And she reported feeling a shadowy illusory person. She was sitting there and she felt this strange person with his arms around her. It was a male. It was really, really creepy. And then he turned off the electrode and the shadowy illusory person would go away. And

then he turned the electrode on and this person would come back. And so, he was arguing that this sense of embodiment can be dissociated.

Now, this particular area—the right angular gyrus—is the locus of where some major blood vessels come together in the brain. So, the argument for this (and this would be true for near-death experiences too) is if you have a sudden lack of blood flow to that region—which could happen from an accident, a cardiac arrest, or an illness; or any other stressor might change the blood flow; or with this electrode, which was certainly changing the polarity on the cells—you get an out-of-body experience. And it's quite vivid.

Since then they have induced out-of-body experiences in people like you and me without opening the skull at all. They did that by putting virtual reality goggles onto people and projecting the image of them out in front of themselves—so like sort of an avatar that's six feet in front of you. And then they take a stick or a pen and run it down your back and then run it down the back of the avatar in front of you.

And so, you see this motion and you feel this motion, and then you leave your body. You move out of your body toward the virtual reality representation of your body. It's a dissociation. So, that means that any of us can have these experiences, and they're probably quite common.

GC: I think that's really fascinating. Because the people that are trying to say we need a non-reductionist model for so-called paranormal experiences, this really pretty much answers that concept, I think.

SB: It does. This is a thing that Matt and I feel very strongly about. We talk about auras and how they can result from a synesthesia. People, very young, start seeing colored auras around others. They're not making it up. They really do see that. But in fact people that have those kinds of really strange synesthesias think

it's perfectly normal. They reach their late teens before they realize that not everybody sees the world that way. It's quite amazing.

Out-of-body experiences, near-death experiences, healing touch, Reiki, a lot of these things, we're proposing neurophysiological explanations for these phenomena that are routinely described as the paranormal. And no wonder. I mean if you have an out-of-body experience, it's real. You're not making it up. And then modern science comes along and says, 'No, no, no, that can't be.' So, people are drawn to the parapsychology world for the lack of an explanation from the more allopathic scientific world.

All this new research into body mapping, and the various body maps—there's a sprawling network of body maps—provides another explanation. Now, it won't convince a lot of people. I live in Santa Fe, and I just gave a talk the other night for a book signing. And Santa Fe is full of very alternative people.

GC: You're supposed to be near some kind of magical vortex or something.

SB: Right. Oh, yes. Of course. And so, you'll never convince people that believe that they are flying to Arcturus star. That's fine. And I don't want to take away a belief system like that. No one ever could. But for people that are seeking—a lot of people are very curious and they're just looking for answers—then what Matt and I provide is yet another way of looking at it. They don't have to give up their other belief system, but this is another way of explaining the phenomena, that I find very compelling.

GC: Me, too. And I have a friend who is a master Reiki practitioner, and she listens to my podcast but she hasn't given me any feedback on that episode yet. So, I'll have to see.

[music]

GC: Now, another one of my listeners, Ron Hartikka, lives in Ann Arbor, Michigan. And he asked me several questions. One was with regard to the peripersonal space. He says, “Do you mean to say that we can tell if someone is near us entirely without the use of our normal senses?”

SB: Well, it depends on what your normal senses are. Normally you see with your eyes. And the peripersonal space around your body is mapped in your parietal lobe; and it’s very actively mapped in your parietal lobe. But most of your normal sense of it has to do with vision and touch. Because your brain is filled with these multisensory regions, so it’s not just like you have areas that work on touch, and areas that work on vision, and areas that work on motor acts. There are a lot of regions that are multimodal. And that’s true for this peripersonal space mapping.

But it’s also true that you can sense when people are in that space. You can very often sense when people are coming up behind you. Now, you might be using some auditory cue. But you get this sort of creepy feeling in your body, because they are—I hate to say ‘invading’ your space—but they’ve come into this area that your brain is mapping.

And yes, these cells are becoming activated when anybody enters your peripersonal space. Most of that’s out of consciousness unless you happen to have your eyes open, and then you can see that they’re entering your space. Does that make sense? Because he’s right that usually there is a visual aspect to it.

GC: I guess the fact that the other parts are mostly acting at an unconscious level is the thing that makes people tend to want to give those sensations some kind of magical explanation.

SB: Right. Well, that’s where the Reiki thing comes in, and the healing touch. Reiki and things like that are used all over the world, and they’ve been used for

millennia of healing. The shamans and people will use these techniques—a very light touch, or just without touching the body. So, Eastern traditions have posited the existence of energy fields around the body that are then manipulated by the healer. And it's a very, very powerful feeling that the healer has and that the recipient has, that they can actually sense that there's some change going on.

Well, Western medicine has never been able to verify the existence of energy fields. That just doesn't fit anything that could be tested. But there is this sense that you have this space around your body, and that your brain is mapping it, and you own it. It's like having this sort of ghostly halo around your body that is mapped in your brain.

So, when something enters that space, and you have a belief that those hands moving six inches over your body are having a healing effect, it's very likely that—given the top-down processing in the brain, which is sort of the fundamental basis of the placebo effect—that will induce very powerful sensations in your body. And so, you intuit that there is an energy field. But it's really your parietal lobe that's doing that, I think—the existence of the energy field—because I don't think there's any evidence for that.

GC: No, I think I've heard of one study where they allegedly put somebody in a completely magnetically isolated room and claimed that something was coming off their hands. But I don't think that's really been replicated.

SB: No.

GC: Ron wanted to know if you could give an example of the map in action that could involve something spooky.

SB: You mean about peripersonal space maps?

GC: Yes. Besides that ghost person that we got when we stimulated the left angulate gyrus.

SB: Yes, the shadowy illusory person. That's certainly part of all this mapping coming together. I have something that's not so spooky, but I love this story. It's about horseback riding.

We have this whole thing in there about shared peripersonal space. And there are quite a few scientists who are talking about manifolds of space, and they're doing experiments with how you carry objects with another person—like if you're carrying a couch or wooden planks—and they're looking at how you estimate the distance and how you share the loads of things like that.

Well, I got really interested in horseback riding on this. I'm not an equestrian, but I was thinking one day, well the horse has a space map. All animals will have these peripersonal space maps. And a human has one too. So, if you're riding a horse, you're probably blending your space map with the horse's space map.

So, I started asking a lot of equestrians about that, and people that were expert riders intuited this instantly. They said, 'Oh, yes. It's out of consciousness, but you're sort of riding one with the horse and the horse is riding one with you, and you're just totally blended.' Now, certainly you've got the skill, and the balance, and the muscles to do this. But there's a communication between you and the horse.

And then I got a call from a woman who said that she knew a guy that had Parkinson's. I guess it was probably in the early stages, but still he was freezing and shaking a little bit. And he's a horseback rider. And when he rode his horse all of those symptoms went away—he had no Parkinsonian symptoms at all. And that was very spooky to me. I don't know whether there was some mapping going

on between the horse and this guy, but he was symptom-free while he was horseback riding.

GC: That sounds like one we have to put in the 'I don't know' box.

SB: Right. Exactly. And I don't know if that's very spooky, but that's sort of about the space. But when you hold a child, or when you're in someone's intimate space, it isn't just that you're holding them in your arms, you're also mapping their space and your space together in this network in the parietal lobe.

It's very active. And it's not in consciousness. Most of these maps are out of consciousness. Your body maps, you can't turn them off. You can close your eyes and not see. You can stick your fingers in your ears and not hear. But you cannot turn off these body maps.

You can't turn off your vestibular cortex, which gives you balance. You cannot turn off your proprioceptive receptors. You can't turn off your skeletal muscles, or receptors, or that whole proprioceptive sense. It just is. And you know where you are in space. You know where your hand is. You can walk to the bathroom in the middle of the night in pitch black and know exactly where you are because of these peripersonal space maps and these body maps.

GC: And you know where your hand is. Like if you wake up in the middle of the night and your arm is asleep, you still know where it is.

SB: Yes. And so, you ask yourself, how do you know that? You know that because of these maps. They're mapping your body as it moves in space.

[music]

SB: And you usually have this sort of peripersonal space envelope around you. That's all being mapped. And it extends with tool use. But it also reacts to other

people. And there are different areas of zones of comfort in different cultures for these spatial maps. So, in Arabic cultures people are comfortable about 12 inches apart from each other, and in American culture you're like 24 inches apart. So, there are cultural differences in all these maps.

GC: So, that tells us that they're not hard-wired, they have to be learned.

SB: A lot of it is learned. Well, the brain is not that hard-wired. It comes out with a default architecture at birth, and it comes out with a genetic patterning. So, you might have a slightly larger parietal lobe than the next person, which might make you gifted, literally, in mathematics, because the parietal lobe is very often involved in mathematics. Einstein had a huge right angular gyrus. He had a huge right parietal lobe—freakishly large.

People are arguing now that this affects certain talents. Like athletes might have a very good mapping of what they call place cells, or grid cells; and also better spatial mapping. And a lot of those maps are, again, genetic defaults—their architecture is there at birth. But then experience flows in and comes pouring in to the brain. And that's how you learn to see and hear. But you develop these body maps. Your motor maps are developed according to what you do. You learn to stand up, and crawl, and then walk, and kick a ball. And most kids learn that.

But if little Pelé down in Brazil learns to kick a soccer ball at age three, he's going to build an incredible motor map for that foot-eye coordination, which you or I don't have. Tiger Woods is out there at age three with a golf club, and this golf club becomes an extension of his body. He's mapping it in his peripersonal space; because it's not just a tool, it's literally in his motor maps and in his parietal maps. And so, he absorbs that from age three and practices 12 hours a day every day.

People that take up musical instruments bring these big motor maps to bear in childhood. And that's the basis of the virtuoso performance in sports, and in music, and in dance. All of that is mapped up from early life.

GC: But you can learn how to do things as an adult, you just can't get quite as big a map to it. Right?

SB: Right. Plasticity is life-long. In the mid 80's they thought that once you were past these critical periods in early childhood the motor map was set, the visual map was set, the language maps were set, and your body maps were set. And they thought that because of strokes. Because people will be 70 years old, they'll have a stroke, it will knock out a function—they'll be paralyzed on the left side, or lose language function, or lose spatial recognition because they'll have neglect of space—and a lot of people never get better. They will just have these deficits.

And so they thought the brain is set in stone early in life and you're screwed if you're going to have the stroke when you're older. It turns out that's just not true, and that there's a lot of remaining plasticity. And a lot of techniques today are being developed to hit the maps—hit the motor maps, the visual maps, the body maps—with extensive practice in therapy, and in stroke recovery, and things like that. And it's driving adult plasticity. And it actually is very effective.

GC: One of the things you talked about in your book was the use of the mirror box. Do you want to use it as an example?

SB: Yes. Rama invented the [mirror box](#). And here's a little anecdote. My son, Matt, was in Rama's lab when he was at UCSD, and he built the first mirror box as an undergraduate. Rama had told him to go out and build this box. It's a box with a mirror down the middle and holes for two hands to go in.

So, let's say you're an amputee and you've lost your left arm. And because you've lost your left arm—normally there's a motor area and a touch area in your right brain that maps the arm; and suddenly the arm is gone—this is like a vacated spot in your touch map, in your motor map. It's like vanished because the arm is gone and you're not getting any feedback from the limb. You look down, and you're not getting any visual feedback or any touch feedback—it's vanished.

So, what does the brain do? The arm map doesn't die. It doesn't shrivel up and leave a hole. What happens is there's migration plasticity from the adjacent areas that will move into that map area. That's the basis of a phantom. What happens is that the adjacent maps to the limb—the upper shoulder and the face, which are the next adjacent maps in the body map—become, whenever they're active, like if a guy is shaving he'll feel it on his phantom. He'll have this sense of having a phantom because he's getting the activation from his face, not from the missing arm.

So, there's all this remapping going on. And quite a few of the patients have severe pain in the phantom. This has to do with probably the loss of the limb, or the limb might be paralyzed for awhile before it's amputated. And so, phantom pain is a big deal. And until Rama it was impossible to treat because the pain was not in the limb, because there was no limb. The pain is in the central representation in the brain. It's somewhere up in the cortex.

So, what he did was he took this box and he said to the amputee, 'Put your good right arm in this box, and look into the box. And now pretend that you're conducting.' So, the person looks into the box and he sees two arms. You see a mirror reflection of the right arm, so you see two arms. And you see the two arms moving: you see your right arm moving and you see a left arm moving.

So, your eyes are looking down at that, and suddenly you see a left arm—which has been missing, but it's suddenly there—and it's moving, and it's quite active.

They do this for a few weeks, and the pain goes away. So, what he's doing by using this visual feedback to the arm representation—the motor representation and the touch representation of the missing arm—he is driving this plasticity that basically takes away the pain. And he can cure phantom pain using this technique.

You can cure a lot of other disorders using this technique too. You can use it with chronic stroke pain. And a classic one is when you break your wrist, say, and it's in a cast for six weeks, and then the cast comes off, and the arm is perfectly good but you still have pain. You can use the mirror box to get rid of that pain, too, because it's centrally represented pain. The pain is not in the periphery, it's in the brain.

GC: And they're using that for stroke rehab now.

SB: Yes, for stroke and for all sorts of central pain syndromes that you can use this to override the mapping in the brain. Because your brain is just sort of stuck with this pain representation, and if you whack it with this plasticity you can undo it.

GC: Well, I could talk to you for hours on end, but I know you don't have that much time. I think that we should head toward wrapping up. You've kind of alluded to this as you've been talking, but what do you think are the main implications of this research?

SB: That's a good question. First of all I just think it's incredibly cool. It's so interesting, when we started this I realized that people don't know that their brain maps their body. They just don't know. I mean it's something that never occurred to anybody. So, there's a lot of neuroscience here to learn. And there are some cool things about learning sports. We have a whole chapter on the motor imagery, and that motor imagery can improve your ability to play just

about any sport. And there are treatments now for musician's cramp that are very interesting.

But for me the most interesting I think is this Bud Craig work at the end of the book, talking about the interoceptive maps. This is just such a new discovery, that you're mapping your internal state of your body through this network that is unique in humans. There's this anatomical pathway that no other animals have. They have it to a lesser degree in the great apes; it's barely there in monkeys. But we have it elaborated in this way where we have these re-representations up in this part of the brain called the right frontal insula, which are the social emotions. And so, we feel pride, and humiliation, and shame, and lust, and disgust in these ways that other animals don't—being such über social animals.

And a lot of things that go wrong with us, a lot of things that make us sick—and you're a physician, so you know this—over half of the doctor visits are for what they call somatopy; for hysteric conversion disorder, all sorts of things. That's a serious example of this, but people have chronic back pain, they have fibromyalgia, they have all sorts of debilitating, chronic problems where the physician can find nothing organically wrong. And they tell the person, 'It's all in your head. Go home. Forget it.' You know? Or they give them lots of drugs, which is probably even worse.

And a lot of these disorders are stemming from a homeostatic imbalance of what these fiber tracks are—what's called the autonomic nervous system—it's coming up and hitting these regions of the brain differentially. And if you find ways to restore that balance, which is what most of these alternative techniques do—even acupuncture will remap the brain, and meditation will drive remapping—people have found these are effective. I think this particular aspect of body mapping provides the very first good answers as to why these things work and why anybody that has chronic pain or discomfort should be trying this stuff.

GC: So, this is probably a related question, but looking forward what are you most excited about? You've been covering neuroscience for twenty-plus years now.

SB: I'm excited about it all. I love it. I mean there's something always so interesting. So, plasticity—I'll give you an example. Mike Merzenich², who's also in the book, he's the guy that discovered adult plasticity. Mike is one of these rare neuroscientists who, rather than just sit there and write academic papers, he decided a number of years ago to actually go out and make things that would help people.

The first thing that he invented was a whole technique for treating dyslexia, on the basis that dyslexia is an abnormal mapping of the auditory cortex and these kids were just hearing the sounds wrong. And you could drive plasticity in the auditory map and you could then give them the ability to hear the sounds appropriately and then they could learn to read. And it works.

What he's doing now, he's got a thing called [Posit Science](#), and he's driving brain plasticity in the elderly. I've interviewed a lot of 80- and 90-year-olds who are doing this. And he's speeding up the brain, he's hitting the brain plasticity, through these games that are basically auditory games. And people will begin to start testing out at age 50, when they're 80.

And he's doing it for brain damaged people, too. It's very exciting to see the fundamental neuroscience actually going out beyond the clinic, beyond the neurologists who often don't really follow this stuff, but into actually helping people. I find that tremendously exciting.

² Michael Merzenich was interviewed in [Episode 54](#).

GC: When I talked to Christof Koch³ last week he said that he felt this was the Golden Age of neuroscience.

SB: It is. And you ought to have Mike Merzenich on some day. You really should. He's just fabulous. [Note: Dr. Merzenich was later interviewed in [Episode 54](#).]

GC: Yes, I talked about his work on the first episode that was about neuroplasticity. That's a subject I can't stay away from because it's just so fascinating.

SB: Yes. Well, all of us have it. And the aging brain is so interesting, because there are natural decrements in the speed of processing and there are natural decrements in the fidelity of the maps, for all sorts of reason. But there are things that you can do to keep yourself tuned up. And it's not doing crossword puzzles, either. That's inadequate. You really need to hit the system harder. That's why Mike is so brilliant, because he's figured out ways to do that.

But then I get interested in protein misfolding, and frontotemporal dementia, which is this incredible disease that Pete Domenici has right now. I think it's all interesting and a never-ending joy and fun to write about this stuff.

GC: Do you have your next book planned, or are you taking a break?

SB: We don't. But I'll give you the idea and see if people like it. Matt and I would like to do a book on poker and the brain. And there are probably about 30 books out there on poker, but a lot of them are sort of psychology, or they're strategy, but not about the fundamental neuroscience of 'this is your brain on poker.'

³ Christof Koch was interviewed in [Episode 22](#).

GC: Well, that will be your best-seller.

SB: We thought that would be fun to do. If we ever get time to write the proposal, we're going to do that. But we're just talking about that right now. It would be fun.

GC: Is there anything else you'd like to tell my listeners before we close?

SB: No. Just to check your website, and look at our website—we're getting more reviews, we're doing a lot of radio, which is really fun—and to just keep an eye on the website. And I will get those references up there, because there are a lot of them. I won't do the 10 boxes full of papers, but I'll do a select thing and point people to where they can learn more about some of this work. A lot of it is in Europe. A lot of it is in Italy, a lot of it is in Switzerland, a lot of it is in England, and a lot of it is in Japan; and less so in the United States.

GC: I'm hoping in a few weeks to talk to Rolf Pfeifer⁴. Do you know his work? He's actually in artificial intelligence, but you know in Europe the artificial intelligence community is really getting into the whole idea of embodiment.

SB: Absolutely. They're doing fabulous stuff. This whole thing about virtual reality and how far it can go is just wide open. And that's a big part of the body mapping that we're talking about—because that's what it taps into, is these maps.

GC: So, the best way for my listeners to reach you would be through thebodyhasamindofitsown.com?

SB: Yes, go to the website, thebodyhasamindofitsown.com and there's a contact page. Or, my website is sandrablakeslee.com, and there's a contact there too. And I get all those. And it's good for me to know that way, because then I can

⁴ Rolf Pfeiffer, author of *How the Body Shapes the Way We Think: A New View of Intelligence* was interviewed in [Episode 25](#).

keep those separate from my other work so I make sure to answer them right away.

GC: Well, you did a good job of answering my email, and I appreciate that. And I've really enjoyed talking to you. Now, the audio version of your book I know is on Audible.com. Did you read that, or did somebody else read it?

SB: No, it was read; and I haven't heard it yet. I just got samples of it the other day. A company called Tantor put it out. Or maybe it's on Audible.com, too.

GC: Well, thanks a lot for being on my show. I look forward to talking to you again some day.

SB: Thank you. I hope so. It was really fun.

[music]

I hope you enjoyed today's interview with Sandra Blakeslee. You can send questions and comments to me at docartemis@gmail.com, or post them on the Discussion Forum which is at brainscienceforum.com. I hope if you're not already subscribed to the *Brain Science Podcast* that you will consider subscribing, either via iTunes, or you can go to my website brainsciencepodcast.com for other subscription options including email subscriptions.

A couple of reminders. One is that I appreciate those of you who have participated in the Audience Survey so far. And I'd like to remind you to do so if you haven't done so already. There's a link for this on the website, or if you are good at remembering addresses, the address is wizzard.tv/survey/brainsciencepodcast.

Also, if you haven't checked out my other podcast, which is called *Books and Ideas*, I hope that you will check that out. It's at booksandideas.com. I have a new episode planned that should be out by the end of October. It's going to be an [interview with Dr. Pamela Gay from the Astronomy Cast](#), and I'm really looking forward to that interview. I got to meet Dr. Gay at Dragon*Con and we really hit it off. I'm really looking forward to talking to her and sharing that with you.

Thanks again for listening. I will be back with you in a couple of weeks.

[music]

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Transcribed by [Lori Wolfson](#)

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