BRAIN SCIENCE PODCAST

With Ginger Campbell, MD

Episode #21

Discussion of the book, *The Body Has a Mind of Its Own*, by Sandra Blakeslee and Matthew Blakeslee

Aired September 22, 2007

[music]

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* I explore how recent discoveries in neuroscience are unraveling the mysteries of how our brains make us who we are.

[music]

DISCUSSION

Welcome back to *Brain Science Podcast*. I'm your host, Dr. Ginger Campbell, and this is Episode 21. Today we are going to be talking about a new book called, *The Body Has a Mind of Its Own*, which will be exploring the implications and applications of recent discoveries regarding body maps in the brain.

Before I start I'd like to welcome any new listeners. Episodes of the *Brain Science Podcast* are intended to stand alone, although I sometimes refer to previous episodes; and a lot of new listeners like to go back and listen to the older episodes. The website for the *Brain Science Podcast* is brainsciencepodcast.com

where you can leave comments. Also there are links there for subscribing to the podcast via iTunes, RSS feed, or even by email. You can also send me email at docartemis@gmail.com. And I try to answer all my email. On the website I have links to the Brain Science Discussion Forum, an Audience Survey, and also to my sponsor links.

This episode is being sponsored by audible.com. There is a link to Audible for getting a free audiobook download at brainsciencepodcast.com. But I now have a direct link. It is audiblepodcast.com/brainscience.

[music]

This is Episode 21 of the *Brain Science Podcast*. Today we are going to be talking about body maps, and I'm going to be concentrating on the new book, *The Body Has a Mind of Its Own: How Body Maps in Your Brain Help You Do (Almost) Everything Better*, by Sandra Blakeslee and Matthew Blakeslee. The key theme of this new book, *The Body Has a Mind of Its Own*, is that our brains have maps of every point in our body, as well as the space around us, which we can call the peripersonal space.

The fact that we have a map of the space around us shows up in the way that we are able to use tools. It's almost as if they become a part of us. Think about what's happening when you eat with a knife and fork, and you basically feel the texture of the food through the knife and you just incorporate that into your map. Now, since the things that we are interacting with in the world around us are constantly changing, these maps of our peripersonal space are also constantly changing.

The Body Has a Mind of Its Own considers the far-reaching applications and implications of these body maps, including how they can possibly explain things like out-of-body experiences, auras, how placebos work, and the healing touch.

This look at body maps relates to our previous discussions about neuroplasticity and it also touches on the role of emotions and unconscious decision making. But probably the key idea is that our mind is embodied. That is, there is an intimate two-way communication between the brain and the body, and this is what generates our consciousness and our mind, as well as our sense of ourselves and our sense of others.

So, first let's consider the question of how do we know where our body begins and ends. One of the basic maps that the brain maintains is a complete map of our body's surface. Now, a map just means any scheme that is a one-to-one correspondence between two different things. For maps related to the body's surface, research indicates that the spatial relationships are highly preserved. So, the map of our body's surface is really our primary physical window out into the world around us.

Now, let's consider a little bit about various sensations. We know that there are the so-called special senses which are vision, hearing, taste, and smell. Today we are going to be talking a little bit more about the so-called somatic senses which include touch; temperature sensation; nocioception, which means pain; proprioception, which is how we know where the parts of our body are and whether they're moving; and balance. These are actually the more primitive senses in the evolutionary sense.

Touch reaches the brain via two major pathways. There is the most ancient pathway that carries pain, temperature, itch, tickle, sexual sensations, and crude touch. We have a newer pathway that carries fine touch information. Another important idea in this book is the fact that the brain contains multiple maps, and that most of these maps are in the cerebral cortex—although I will be talking about a few maps that are in lower parts of the brain.

Maps you've probably heard of are the primary motor map and the primary sensory map. These are the areas that correspond to the primary motor cortex and the primary sensory cortex. These were actually discovered by Penfield back in the 30's and 40's. He was working with people with epilepsy and they were trying to remove parts of the brain where they thought the seizures were coming from. And he basically went and stimulated all over the surface of the brain trying to determine what areas did what, so as to not damage anything that was important. This is where those maps—the ones that have the really big lips and the really big hands that you see drawn on the brain—his work is the basis of these maps.

But it turns out that we also have primary visceral maps. Those are ones that come from the inside of our body—our various organs. These are uniquely well-developed in people, and they seem to be intimately related to our ability to feel lust, disgust, sadness, joy, shame, and humiliation. Later on I'm going to talk more about how these visceral maps end up getting tied to our emotions.

The fact that our brains are also maps of the space around us is a fairly new realization. And one of my goals in this episode is to explore the implications of this realization. The other important new idea is the fact that some of these body maps are somewhat plastic. This is obviously of profound significance, especially in terms of treating disease. So, again, I want to emphasize the fact that our body and our brain exist for each other. Brain development is dependent on embodiment.

For example, people that are born deaf do not develop auditory maps, and people that are born blind do not develop visual maps. But we also know those areas of the brain that would normally be devoted to these maps end up getting mapped into something else. We talked about this in the episode on neuroplasticity. A key idea is that in the real world there is no such thing as disembodied

consciousness. This is one of the realizations that is propelling current work in artificial intelligence.

Let's think a little bit more about why embodiment is so important. Experiments show that if you take an animal like a cat and carry it around in the world as it's growing up, it won't even develop normal vision. Because it turns out that, at least for mammals, we need to have feedback from our own bodily movements in order to give meaning to what is seen. Sensation only makes sense as it relates to your embodiment.

In considering these maps in a little bit more detail, I did mention that Penfield was the first to map the primary sensory cortex and that he found the motor cortex had a similar map. I mentioned the big lips and the big hands. These are areas that have a lot of cortex devoted to them in people. But the other areas of the brain that have other kinds of maps are, not surprisingly, more difficult to explore and understand.

But one thing we do know is that if you stimulate the premotor cortex, that causes more complex movements. Remember that the premotor cortex is involved in planning movements before we do them. In fact, with patients it has been shown that if you stimulate the motor cortex it will cause a sensation of involuntary movement, whereas if you stimulate the premotor cortex the person usually says that they suddenly wanted to do the movement. And this fits what we know about the role of the premotor cortex in planning motion. Now, another really older part of the brain is the cerebellum, which turns out to also have at least two body maps.

In studying other animals we can confirm that the body maps are very unique to who we are and what we do. In a raccoon it is found that 60% of its cortex is devoted to its fingers and palms. Think about what raccoons do. They are constantly picking stuff up with their hands. In contrast, a mouse has half of its

sensory cortex devoted to its whiskers, because in a mouse the whiskers are one of the most important ways that it learns about the world around it.

And then there's a funny picture in the book that shows a pig and how if you drew it according to how much of its brain was devoted to parts of its body, it has a huge bulge of brain tissue devoted to the snout. So, you would end up with a pig that has this huge snout if you drew it according to how the cortex is mapped.

Not surprisingly, once we know that there are a lot of different body maps we can begin to appreciate the possibility that conflicts might emerge and that this might be a problem in certain conditions. One of things that the authors talk about is the fact that you can have a conflict between what they call the body schema and the body image. The body schema is the felt sense based on the physical properties of your body, whereas your body image stems from learned attitudes about your body. And so, for example, a person who has been fat and loses weight may still have a body image of being fat.

Besides the sense of touch there are other ingredients that contribute to our body schema, and most of this occurs almost entirely outside of our consciousness. There are receptors that sense tiny motions in muscles and joints. These contribute to proprioception, which is knowing where our body parts are and whether they're moving. And there are the receptors in the ear that are devoted to balance. The body schema is the felt experience of your body that is constructed from all the various maps. This idea was actually first proposed by two British neurologists back in 1911.

One thing that's interesting is the fact that our body schema can expand to include our clothing. So, for example if a person is wearing a hat, you will typically see them duck when they enter a doorway. And it appears that a lot of body therapies like Tai Chi, Yoga, Feldenkrais, and various other ones probably work by using our body schema awareness.

Now, the posterior parietal lobes contain a lot of maps where various different kinds of sensory information come together along with the plans from the frontal lobe. It is thought that this area might constitute the center of your embodied self embedded in the wider world. We will come back to this again later.

Weird illusions can occur if we get information that is inconsistent and contradictory. We know that the brain tries to come up with a picture that makes sense when the information conflicts, but sometimes the conclusions it draws actually don't make sense. There are a lot of examples in the book of various illusions that can be created in different ways.

The body image is different from the body schema because, while it's based on our body map, it also includes our beliefs and our memories. Now, if we are going to understand how body image can become inaccurate we have to appreciate another important principle about how our brains work. While the structure is hierarchical, since information is being fed forward, there is no ultimate top where everything comes together, because as the information is going up to higher levels it is also always being fed back down. The feedback fibers are said to outnumber the feedforward fibers by 10 to 1.

This massive feedback implies that the mind operates by means of prediction. As they say in the book, "Perception is not a process of passive absorption, but of active construction." So, basically our brain is constantly comparing incoming information to what it expects or believes. And it can even alter the incoming information to fit its expectations. Our predictions and our beliefs can actually work against us.

So, our understanding of reality is constructed in large part according to our beliefs and our expectations. And these, of course, are based on our past experience. And then when we come back to the body image it's an amalgam of these beliefs. And our body image becomes fairly fixed in our teenage years. So,

if we are overweight when we are young but lose weight later, it can be very difficult to really get that new body image to stick.

Problems with these body images not being accurate appear to have a role in certain diseases. Anorexia nervosa seems to involve extremely abnormal body images, and it is hoped that this new knowledge about body maps might provide clues for more effective treatments. In fact, there is a whole area of research that holds promise for various so-called body dysmorphic disorders. I don't have time to get into the body image issue in much detail because I want to talk a little bit about some of the other areas where these new discoveries about body maps are being applied.

[music]

Over the years various experiments have shown that people can improve at various skills like sports and playing musical instruments by imagining the activity. And it turns out that motor imagery is what really works. This seems to be based on the fact that there are higher order maps that represent the activities before we actually do them, because when we do motor imagery these areas are activated but the actual primary motor cortex is inhibited. Now, in order to benefit from this kind of imagery you actually have to have a certain level of skill, because otherwise you won't have those higher order maps.

Another aspect of doing a skilled activity comes back to that whole predictive nature of perception. For example, when you're returning something like a tennis serve or hitting a ball, you really could never hit a hard tennis serve if you had to wait for all the sensory information to get to you. You actually have to do some prediction based on the very small amount of information that you have at the very beginning of the serve. And this, again, is based on the experience that you've built up.

So, the new knowledge basically shows that when someone is imagining an activity it activates the same part of the brain that is used to do that activity—especially the part of the brain that does the premotor part of the activity. This is also providing the basis for a new approach to developing all kinds of prostheses. For example, new ways to control artificial limbs and ways to bypass damage to primary motor areas of the brain.

One of the things about the idea of these body maps and the fact that they are somewhat plastic, is that the fact that they are somewhat plastic is what gives us opportunities for coming up with new ways to treat various problems. At the same time, the idea that these body maps could be broken or distorted gives us a way of understanding a lot of different disorders, some of which used to be thought of as being psychological.

For example, there are people who are called amputee wannabes, because they just have this sense that a certain part of their body really isn't supposed to be there and they want to have that removed. There is also something called the alien hand syndrome, when the person has the sense that their hand is not really part of them. And then there are people that actually feel like they have an extra arm, or an extra leg, or they have limbs that they have the sensation of them disappearing. These are all caused by distortions of body maps. There is also evidence that something like this is going on when someone has an out-of-body experience.

Another aspect of body mapping has to do with our ability to perform a learned motion. For example, when we see a fork we know exactly what to do with it, we see a doorknob we know exactly what to do with it; almost unconsciously. When someone loses an ability to do something like use an object that they knew how to use before, this is called apraxia.

Back in the 60's a guy named Gibson came up with something called the theory of affordances, which was the idea that people and animals look at the world in terms of its behavioral potential instead of the objective what's there. You see doorknobs as things to turn, and so forth. And so, you would see the world differently than, say, a bird that comes into the room and would see a doorknob as something to perch on.

I think that this makes sense when you think about the fact that, for example, if you see a computer and you're a person that uses computers, you see that as something to use. Another person who doesn't use that particular computer would probably almost entirely ignore it.

Coming back to the mapping idea, the prefrontal cortex seems to be involved in allowing us to know how to grip different things appropriately. It is thought that this is made possible by an automatic perception at the preconscious level that involves higher order body maps and space maps. If you lose one of these higher order maps, for instance, you could see a fork and know that it's a fork, but not have a clue how to pick it up anymore.

[music]

Let's consider some more about how our brains map the area immediately around us. I think this is a particularly fascinating subject. Some researchers think that this ability to map the area around us is one of the things that sets the best athletes in sports like basketball and soccer apart. But on a practical level it means that our sense that we know someone is nearby is not imaginary or mystical. In fact, I think that's the biggest take-home point about this information about our sense of the space around us. It explains a lot of things that people have tended to want to explain with paranormal or magical thinking.

As usual, a lot of what we know comes from observing what happens when things go wrong. For example, a person who has a stroke to the right parietal lobe will then have total neglect of everything on the left, including that part of their body. I mentioned the parietal lobes earlier. It used to be thought that they were basically just devoted to sensory functions, because lots of sensory information comes together in the parietal lobes. But it turns out that they're also involved in motor activity, because they have massive direct connections to the frontal motor system.

Here is another key idea. The parietal lobe is not purely sensory, and the frontal lobes are not purely motor. In fact, it seems like the more we learn about the brain the more complexity arises, and the less we can say one part of the brain does only one thing. Basically it turns out that the senses interact with each other very profoundly.

A simple example of this is that you will see something sooner if it makes a noise. What you hear influences what you feel; what you feel influences what you hear. Consider this. When you're watching a movie the sound is not really coming out of the actor's lips, yet you have the sensation that it does.

We also have cells in the premotor cortex that react to sensory input when their particular area of the body is approached; which makes sense from a survival point of view. There are people who have various sensations that get mixed together, and this is called synesthesia—like when a person might see colors with words, and things like that. One example that is talked about in the book is a patient that had what was called emotion-color synesthesia. So, she would see auras around people that were reproducibly related to her emotional attitude toward them.

The bottom line is that the fact that our body and peripersonal space maps are very flexible may lead to explanations for a lot of different strange experiences,

including explaining why some people see auras. We know from research that Buddhist meditators show decreased parietal lobe activity during deep meditation, which might be the source of that sensation that their body has disappeared. And several experiments have shown that if you stimulate the right angular gyrus—which is part of the parietal lobe—it can cause an out-of-body experience. Stimulating the left angular gyrus seems to cause an experience of a strange shadowy presence that goes away when the stimulation is stopped.

People vary in their awareness of the space around them, and research indicates that this seems to relate to the so-called place and grid cells. Both place and grid cells are located in the memory-forming hippocampus, which as you may recall is much older than the cerebral cortex. The place cells map the space around you in terms of your environment.

They were first discovered in 1971 in rats. They discovered that if they were recording from the neurons in rats, there were certain neurons that always reliably fired according to where the rat was in the environment. And this was reproducible. In fact, they could even tell where the rat was by just which ones were firing.

Since then they have documented that place cells exist in people. And this is probably how we get around in the dark, like say in our bedroom or any familiar space. Basically we have a map of that space in our brain that seems to be created by these place cells. And we seem to make a new combo of these place cells to represent a new place fairly rapidly if we go into a new environment.

The grid cells seem to map the space independent of the environment. They were found in rats in 2005. They haven't been documented in people yet, but it's expected that they will be.

[music]

The overlap between our body maps and our maps of our peripersonal space may be the key to understanding how various healing touch modalities work. Remember that there is a blending of objective and subjective information, so that we actually perceive a subjective experience as objective. Our beliefs strongly influence what we experience. This idea that the peripersonal space can be harnessed to treat and cure human ills is actually already well accepted in cultures around the world.

The explanations they give for how their treatments work cannot be documented by science. We do know that these treatments do have some effectiveness. And this is probably due to the fact that people expect them to work, and because our body schema is flexible and creative, so what's going on gets incorporated.

What I mean by this is that, say someone is doing Reiki on you—which is a healing modality where they don't actually touch you—but people commonly have a sensation related to the person, and they could tell you where the therapist's hand is above them. And skeptical people tend to think that this is all imaginary.

But what I'm saying is that since our body maps actually extend out into the space around us, we probably really can sense the person really close to us doing therapeutic touch—which also doesn't involve actual touch, even though it's called therapeutic touch. So, the sensations that the person feels are a combination of the flexibility of their body map to reach out to that other person, and what they believe is happening.

Think about it. Almost everyone has had an experience of sharing this peripersonal space. It could be when you're listening to a live band and you really sense how the people around you are feeling. The most extreme example is, obviously, having sex, people commonly have a sense of merger with the other person during this. The point is that these experiences might be explained by body maps and we don't need to invoke mysteries such as quantum mechanics.

[music]

Does this knowledge change the way that we see our bodies, and does it offer clues to what might happen in the future in terms of things like virtual reality? In Japan monkeys have been trained to use tools. This takes a lot of training because, unlike great apes, they don't really have any innate ability to do this. But they can be trained to do it. And once they're trained to do it it's been shown —in this case they do have electrodes in their brains—that the visual receptive fields involving the hand and the shoulder (they're teaching the monkey to use a rake) actually expand when the monkey has been taught to use the rake. And so, this is like what we do when we are using a tool.

The point is that the body maps are flexible and they extend out to include things like tools. This seems to be happening in the body maps in the parietal lobe with cooperation from the frontal motor system. So, it makes our body schema amazingly flexible. Think about what happens when you do something like play tennis. I can say from my own personal experience that I definitely, when playing tennis, sense my tennis racquet as being a part of my body. I have often noticed this. So, when I read about this in this book it really resonated for me.

They point out that this can include something more than just a tool. It can actually include an expansion of your sense out to where your car is when you're driving, for example. Have you ever driven under a low overpass in your car and found yourself ducking automatically? You feel weird, but that's just because your body schema has kind of incorporated the car. This also underlies our ability to become so immersed in visual worlds like video games, and even when we're watching sports and we see somebody get hit someplace painful and we automatically sort of cringe.

This brings me to a topic I think that we have talked about before, which is the mirror cells. These are the neurons that light up when we see someone else doing

something. According to this book, mirror cells were first discovered by accident in a lab in Italy in 1991, when a grad student came into a lab that contained a monkey whose brain was wired up for an experiment. What they were doing was they were having the monkey pick things up with its hand, and they were recording from the premotor cortex—the part that would be stimulated right before the monkey actually did the picking up activity with its hand.

Well, the student came into the room and he had an ice cream cone. And he picked up the ice cream cone and took it toward his mouth to lick it. And when he did that they suddenly noticed that the neurons in the monkey's brain for his hands were going off. He was having a response as if he was thinking about moving his hand toward his mouth. So, this was the discovery of the mirror neurons.

It has since then been discovered that we have a sizable subset of neurons in the motor map that also represent perception of the same action that they code for doing. In the monkey they found that it is in the parietal and prefrontal cortex and that it links to parts of the brain that process facial and body movements, and hand actions. The premotor mirror neurons are active only when the monkey is either acting or perceiving an action. And some of these mirror neurons seem to be coupled to very exact movements.

They also found mirror neurons in the touch and movement maps of the parietal lobes. And this was an area they previously thought was only devoted to space perception. So, here again we come back to the theme that the more we learn, the more we find that almost every area of the brain does more than we used to think.

The theory is that we should think of the mirror neurons as body maps that allow us to sort of run a simulation of what another person is doing, so that we can understand what they're doing. It makes me think of the saying, 'It doesn't take a mind reader.' That is, when somebody is watching someone's behavior and they

say, 'It doesn't take a mind reader to see that they're upset,' or something like that. This is obviously a function of having mirror neurons and being able to figure out what's going on with a person.

Mirror neurons also seem to be part of what allows us to become so deeply involved in watching others, like when we're watching a movie or we're watching sports. One interesting thing is that the mirror motor neuron system is more active the more expert you are at the thing that you're watching. So, if you're watching an activity that you are really pretty unfamiliar with, your mirror neurons may not be all that active. But if you're watching somebody do something that you do yourself, they really fire off. Which might explain why we prefer to watch things that we have done ourselves. Like a lot of people that watch sports like to watch sports that they have played themselves, in preference to sports they haven't played.

One interesting implication of mirror neurons is that they might offer an alternative to the hypothesis that we are hard-wired with brain modules for things like language. Instead it might be that the mirror neurons form the foundation for the ability to learn by imitation. Some scientists believe that mirror neurons are the basis for the great leap forward in human evolution, because they set the stage for what is known as the horizontal transmission of culture.

One thing that supports the idea that mirror neurons could form the basis for language acquisition is the evidence that the same structures that produce language in the brain participate in comprehending it. Also we know that while newborns don't talk, their mirror neurons kick in within minutes of being born. And consider how much children learn by imitation before they ever learn how to talk. We also know that language is more closely tied to our body maps than you might think. It's been shown that if you read the word 'lick' it makes the tongue area of the brain light up, and a word like 'kick' activates areas related to the leg.

Besides helping us to understand what people are doing, our mirror neurons also help us to anticipate what others are going to do. And this is important for us to be able to coordinate our actions. Think about the fact that you don't really see lower animals doing activities that are coordinated in the way that human beings can coordinate their activities.

Mirror neurons are largely active outside of our conscious awareness, but they do definitely affect how we react to others. It has been shown through testing that people are more likely to be persuaded by someone who is mirroring their mannerisms. Another aspect of this whole unconscious element of mirror neurons is that it might provide part of the explanation for how we can know things without conscious thought—another blow to the whole paranormal mind reading idea.

[music]

When it comes to the mirror neurons that relate to reading emotion and experiencing empathy, these are deep inside the cortex in a part of the brain called the insula and the anterior cingulate cortex. Studies have shown that women who have higher empathy scores show more activity in this particular area of the brain. And on average this area does tend to be more active in women, as Dr. Brizendine mentioned in her interview.

There is also some evidence that perhaps mirror neurons are weak or absent in this area in children that have autism. Another aspect of mirror neurons is the fact that if you are touched or you see someone else touched it activates the same primary touch areas. So, for example, someone touching your hand and you seeing someone else's hand touched, both activate the primary area related to the hand. And you can't turn off the mirror neurons.

OK, so now we are ready to talk a little bit about some of the emotional aspects of body maps—now that we've come down to that deep part of the brain known as the insula. It turns out that there is a relationship between emotional awareness and visceral awareness—that is, awareness of the signals that are arising from within your body.

One thing that shows the importance of the right frontal insula is an experiment that was done where they tried to see how well people were able to follow their own heartbeat, and then they also gave them tests about empathy. And what they found was that the right frontal insula had the greatest activity in the people who were best able to follow their own heartbeat, and that these same people had the highest scores on standardized tests for empathy.

So, it seems that the insula maps are related to homeostatic self-regulation. Your insula has mapped to it sensations from your body's interior and sensations from the surface that are related to homeostasis, like itch, pain, burning, tickle, cold, hot, sensual—all those primitive somatic sensations.

In fact, in lower vertebrates this information gets integrated at the base of the brain; so it's very fixed. For example, if a frog sees a fly its tongue will shoot out and catch it. But if it's sitting in a room with flies hanging from strings it will starve to death, because it's triggered by the motion. And that's a fixed thing; it's not adaptable. But the mammalian cortex gives rise to the ability to form a detailed and versatile map of sights, sounds, and actions.

The evidence is that only primates really have rich insular maps. Rats, for example, have very rudimentary insular maps. In a rat, things like pain, itch, sensual touch, and these other ancient sensations get integrated at the base of the brain and in the subcortical emotional centers. And this is actually true for other four-legged animals like cats and dogs.

Primates have rich insular maps, and in people they're even richer still. In humans it appears that there is even another level of integration, and that is that information that's coming in from both insulas gets routed to the right frontal insula, which is the area related to empathy. This appears to be how we get a remapping of our basic bodily functions into social emotions. So, we feel something like, for example, disgust as a physical sensation.

In people the right insula lights up when we feel emotions like love or hate. It also lights up when we have strong physical sensations like pain. This seems to be where conscious physical sensation and conscious emotional awareness co-emerge. It connects the state of your body with the state of your brain, and gives rise to your sense of your emotional self and the emotional now. So, you could say that this is where the mind and body unite.

The right frontal insula integrates the mind and body through strong connections to three other brain regions: the amygdala, the orbital frontal cortex, and the anterior cingulate gyrus. The amygdala is the area that connects strong emotions to experiences, people, and things. The orbital frontal cortex is that area in the frontal cortex that is involved in self-discipline, setting plans and priorities, and is really highly connected to the reward and punishment feedback loops that we've talked about in the past. And the anterior cingulate gyrus seems to allow for monitoring the results, especially in terms of how they relate to our emotional goals. But it also has a full body map, which the amygdala and the orbital frontal cortex do not appear to have.

Imaging studies consistently show the right frontal insula and anterior cingulate gyrus lighting up together. And some researchers think that this lighting up together means that our emotions, feelings, motivations, ideas, and intentions, that this is where they're combined, and that this is a key element of what makes us human. This idea was proposed by Arthur Craig who was one of the first to unravel the unique wiring of the right insula. And don't forget, we've talked in

the past about the work of Antonio Damasio, who has long argued that emotions and decision making are intimately connected.

[music]

Another area where body maps provide a potential for explanation is in beginning to understand the power of belief. For example, with pain it is clearly true that what you believe about pain and other visceral sensations has a powerful feedback effect. And research shows that there is more interaction between the central nervous system and the immune system than we used to think. This interaction between what we believe and our body maps probably explains why beliefs can make people both sick and well. And it probably explains why treatments that don't seem to have a scientific basis often are effective.

This has been well documented in things like using placebos. When you believe a treatment is going to work, your body releases pain relieving chemicals, and you begin to interpret your symptoms differently. The content of the particular belief that you are basing your hope on doesn't really seem to be all that important. I think this makes a lot of sense from my own personal experience, both as a patient and as a physician.

For example, when I was younger and I used to have a lot of sports injuries and I would get hurt and I would go the emergency room, and I would be worried that I had a broken bone or something, I commonly experienced that once I saw the x-ray and that it wasn't broken, the pain seemed to immediately become less. That's one reason why I don't have any problem with ordering x-rays on people when I see them in the emergency room, even though I already know that they don't have a broken bone. Because I know that having this x-ray is going to make a difference to them.

Also, I don't think that any doctor that has any level of experience would argue with the basic fact that whether people believe in a treatment or not makes a difference about whether or not it works. I've always thought that this was very much to do with the fact that most of healing happens within our bodies, and these models with regards to body maps really make a lot of sense to me.

[music]

We now know that we have all these different maps in our brain. So, how come we never—at least if we're healthy—lose our sense of who we are? Or, as they say in the book, "Why doesn't your 'youness' of you ever simply get lost?" This new research could lead to a whole new area of science, which they call the neuroscience of the self. One of the things that we know is that only humans, great apes, elephants, and possibly dolphins can recognize themselves in the mirror. And this is considered to be a very significant sign of an ability to tell the difference between self and others.

It's logical, I think, to assume that the constant sensory feedback that we get from our bodies is very important to our sense of self. For example, you can get a visual illusion that another hand is part of you, but only if the position of that hand matches the position of your real hand. In normal circumstances, if the hand is off at a wrong angle you automatically don't think it's yours. This indicates that the match between our internal maps and our sensory input is very important to our sense of who we are.

There are two brain areas that seem to specialize in this multisensory body-related information. One is called the extrastriate body area. And this is the area that lights up if you look at another person's body or body part, or you move yours. So, say, if you move your hand or look at another person's hand, this extrastriate body area will light up. And this area seems to communicate with the second area, called the temporal parietal junction. Within this we have the right

angular gyrus, which is the area that seems to give us a sense of being localized in our body.

It has been experimentally shown that stimulating this area can cause an out-of-body experience. This is the area that can become less active during deep meditation. And also there was a recent experiment by Marco Iacoboni at UCLA which showed that if you knock this area out temporarily, using transcranial magnetic stimulation, people lose their ability to tell the difference between themselves and others.

[music]

Before I close I'd like to consider a few final points. One is that despite the flexibility of our body maps, the core infrastructure of our brain and body maps is more or less fixed. What I'm saying is that the neuroplasticity elements are relatively limited compared to the overall whole. Now, of course this may turn out to be less true than we think at the present time, but that's the current evidence.

A question that might arise is does this information about body maps mean that our sense of self or our sense of free will is an illusion, like many claim? I think the best answer to this is the quote on page 208. "The illusion of free will is that free will has infinite scope rather than being a flexible set of feedback loops between higher order body maps and emotional and memory storage systems in the brain. The illusion of self is that self is a kernel, rather than a distributed emergent system."

One of the key ideas I think that we can take away from this discussion of body maps is that it reinforces the fact that there is no one place in the brain where everything comes together; or, as the authors say, "It's all distributed." So, when

we talk about localizing a specific function or trait we're really talking about discovering the loops of information or circuits, not a specific point in the brain.

We are increasingly discovering new maps in our brain that map our body's surface, internal signals from our body, and the area close around our body. These maps are related to our ability to perceive the world around us and interact with the world around us, as well as our ability to understand others and to feel emotions, and to make decisions that are related to what we see and experience, and related to our emotions.

This has been a relatively brief discussion of some of the recent discoveries related to the various body maps that help our brains make us who we are. We have had a glimpse of how these maps can begin to explain some previously mysterious aspects of brain function. These maps suggest hope for new treatment approaches for some of the most difficult problems like chronic diseases that result from stress, and chronic pain.

[music]

The Body Has a Mind of Its Own is an easily accessible book for readers with all different kinds of backgrounds. And as I mentioned before, it is available on audible.com. New users of Audible.com can get a free audiobook download by going to audiblepodcast.com/brainscience. Your support is greatly appreciated.

I do have one criticism of this book, and that is the fact that it doesn't have any references or a bibliography. I have made a list of all the scientists that are mentioned in the book, and I hope within the next few days to get this list up in the Show Notes along with some links, as soon as I have time to track links down to the relevant people. If you happen to see the list of scientists on the website and you know some good relevant links, feel free to drop me an email at docartemis@gmail.com.

[music]

As always I appreciate feedback, and my preferred place for you to give feedback is at the Discussion Forum, which is at brainscienceforum.com. But you can also leave comments on the website brainsciencepodcast.com. I'd like to remind you to participate in the Audience Survey. This is located at wizzard.tv/survey/brainsciencepodcast. There is also a link for this on this on the website brainsciencepodcast.com. Your participation in this will be very helpful to me.

One other personal note. I am going to be going to the Podcast and Portable Media Expo, which is being held in Ontario, California, from September 28th through the 30th. If you are going to be there I hope that you will track me down, because it's always fun to meet people in person that you have only known by voice. So, please be sure to let me know if you're going to be there.

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

[music]

[music]

Transcribed by Lori Wolfson
All errors or omissions responsibility of the transcriber