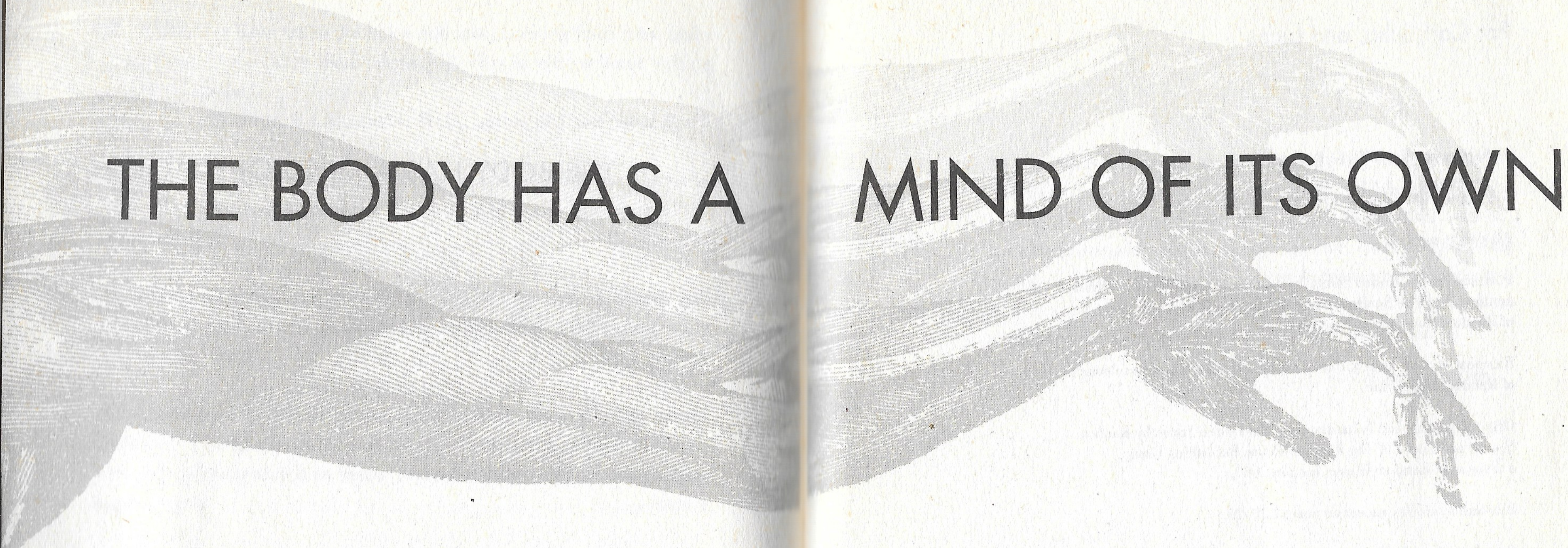

# THE BODY HAS A MIND OF ITS OWN

*How Body Maps in Your Brain Help You Do (Almost) Everything Better*

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inherent parts of the concept of the body, just as an accomplished pianist sees not just individual keys but whole interrelated harmonic complexes brimming with possible melodies that can be extracted from it as wholes, not as individual finger and hand movements.

You also see the world in terms of conserving energy and protecting yourself from harm. According to Dennis Proffitt, a psychologist at the University of Virginia, you have a natural tendency to view hills as steeper when you are tired, less physically able, or carrying a heavy load. If you think you could hurt yourself, inclines appear greater. The distance to the ground seems farther. Your perceptions of the world are modulated by your brain to keep you from danger.

CHAPTER 7

# THE BUBBLE AROUND THE BODY

*or, Why You Seek Elbow Room*

Margaret Wertheim was promoting her book *The Pearly Gates of Cyberspace: A History of Space from Dante to the Internet* when an anthropologist in the audience stood up to tell a remarkable story.

There is a tribe in Namibia wherein each person is born with a kind of self-space around the body. This self-space is like a bubble that extends beyond the body and, being attached to the body, moves as the person moves. And because this envelope of self-space constantly intermingles with other people's self-spaces, individuals in the tribe are never alone. They wonder, the anthropologist said, how we in the West can possibly see ourselves as isolated points in space. They feel infinite pity for us. They wonder how we bear it.

The tribe, it turns out, are the Himba, a nomadic people who live in Kaokoland, a harsh desert in northwestern Namibia adjacent to the aptly named Skeleton Coast, where they tend cattle and goats. For tourists on safari, they are an exotic spectacle. Himba women cream their bodies twice a day with a mixture of rancid butterfat and ground ocher scented with the aromatic resin of a local shrub. The cream gives their bodies an intense reddish glow. They are beautiful.

But for scientists who study the brain, the Himba are a window into one of the more wondrous ways that human beings perceive the world around them. Here is a culture that explicitly posits the existence of personal space around the body. We in the West talk about our metaphorical "elbow room" and the like, but few people take it literally. The Himba acknowledge this bubble of personal space, navigate it, share it, mingle in it.

To grasp the nature of self-space, you need to repeat that little exercise from the Introduction: Put your arms straight out in front of your body, as far as they can reach. Keep your hands flat, fingertips extended straight ahead. Now wave your arms up and down and sideways. Make great big circles from over your head down past your sides. Pretend you're Shiva with four arms so you cover more territory.

Now imagine all the space that your arms have passed through. This is the personal space around your body—what neuroscientists call peripersonal space—and every inch of it is mapped inside your brain. In other words, your brain contains cells that keep track of everything and anything that happens within the invisible space at arm's length around your body. When you observe or otherwise sense objects entering that space, these cells start firing.

The reason is practical. As you move through the world, your brain needs to know exactly where your body is positioned in space. You need to locate objects approaching your body—like someone moving his fingers closer and closer to your belly intending to tickle you, or a low-hanging branch on a mountain trail, or a softball speeding toward your mitt. You need to move around, reach out, pull away, approach, and defend.

How this space is represented in your brain and how you use it to navigate your world is a fascinating tale that is just now emerging from laboratories around the world. But before we get to the science, consider some examples that are closer to home.

Many people swear that they see auras around other humans. Could auras be real in the Himba sense of peripersonal space? Can the perception of auras be explained in terms of brain physiology? There is evidence from a scientist in England that the answer, at least some of the time, is yes.

Have you ever been to a party when someone, most likely from another cultural or social background, stands much too close to your face? There he is, eight inches from your nose, jabbering away in a friendly tone, oblivious to the discomfort he is inflicting on you. You back away, just a little half-step, and reestablish a proper speaking distance. But then he follows, and again he's in your face. You might repeat this many times



until he backs you into a wall. Your personal space comfort zone, which you learned from your own culture, is being invaded. If the parts of your brain that map your body and its bubble of near-space could talk, they would be screaming, "Get me out of here!"

In another example, great basketball players like Bill Bradley and Michael Jordan or legendary soccer players like Pelé and Mia Hamm have extraordinary physical abilities—lightning-fast reflexes, excellent peripheral vision, strength, agility, and the like, all of which have been studied scientifically. They practice harder and longer than most elite athletes, giving them the extra edge that defines each superstar.

But there is one trait they all share that has not been explained adequately. When such athletes are on the court or field, they are mapping the space around them and people in that space in ways that most of us cannot match. Their personal space and body maps, along with a newly discovered mapping system called grid cells, seem to be exquisitely developed, which may be one reason they score so many baskets and goals.

## Fenway Park

Peripersonal space was first explored systematically thirty years ago by Edoardo Bisiach, an Italian neurologist who is now retired and living in the countryside between Milan and Lake Como, where he grows camellias, peonies, and tea roses. Bisiach believes that the best window we have for understanding our peripersonal space mapping is through stories of when it fails.

A relatively common failure of space mapping is called hemispatial neglect, or "neglect" for short. The condition is usually caused by a stroke in the right parietal lobe. A neglect patient is completely unaware of the left half of space, the left half of her own body, or both. The unawareness is complete. She doesn't even know that the left half of the universe and the left half of her own body are gone from consciousness and memory. Fortunately, neglect tends to fade in just a few days or weeks.

In a classic 1981 experiment, Bisiach asked neglect patients to close their eyes and imagine the famous Piazza del Duomo in the heart of Milan. The Piazza, with its magnificent basilica, palaces, and statues, is as familiar to Italians as Times Square is to Manhattanites or Piccadilly Circus is to Londoners.

### DENIAL, A FORM OF NEGLECT

These symptoms sound odd, but when the right hemisphere is damaged, spectacular delusions arise out of your disorganized body schema. Listen to Dr. Anna Berti, a neuroscientist at the University of Turin in Italy, interview one of her patients, C.C., whose paralyzed left arm rests in her lap next to her good right arm.

"Can you raise your right arm?"

"Yes." C.C.'s arm goes up.

"Can you raise your left arm?"

"Yes."

There is no movement.

"Are you raising your left arm?"

"Yes."

"Can you clap your hands?"

C.C. moves her right hand to the midline of her body and waves it in a clapping motion. The left hand is motionless.

"Are you sure you're clapping?"

"Yes."

"But I can't hear a sound."

C.C. replies, "I never make noise when I do something."

Insistent denial of paralysis was long thought to be a psychological problem, Berti says. It was a defensive reaction to a stroke: *I am paralyzed, it is so horrible, I will deny it.*

But it is not a Freudian dilemma. Rather, it is a variation on neglect, which has a different underlying brain pathology. Neglect usually involves the parietal lobe. But brain damage in denial patients tends to occur in the supplementary motor area, which is involved in the mental simulation of movements. When you close your eyes and simply imagine a golf swing or skiing maneuver, you activate this part of your brain.

When Berti asks C.C. to raise her left arm or clap her hands, the region that imagines such movements produces a familiar pattern of activity in her brain. But the regions that maintain awareness of and carry out movements are not working.

The conflict is overwhelming. C.C.'s sense of having moved via simulation is powerful. Awareness is absent. Paralysis is complete. Her brain's solution: Confabulate.

If prodded for hours, patients make up stories to explain their lack of action, Berti says. One woman said her arm "went for a walk." A man claimed that his motionless arm did not belong to him. When it was placed in his right visual field, he insisted it was not his.

"Whose arm is it?" Berti asked.

"Yours."

"Are you sure? Look here, I only have two hands."

The patient replied, "What can I say? You have three wrists. You should have three hands."

"You are facing the Basilica," Bisiach tells each patient. "Tell me what you see. Describe all the buildings."

Scanning the scene with their mind's eye, the patients faithfully name all the buildings on the right side of the majestic plaza. They ignore structures to their left.

"Now you are standing at the gate of the Basilica, looking out," Bisiach instructs. "Tell me what you see."

This time the patients accurately name all the previously neglected buildings that are now on their right. They do not mention those to their left, even though they had just named them moments before.

This would be like an American viewing a familiar baseball field, say Boston's Fenway Park, from behind home plate. He could describe first base, the Red Sox dugout, and the infamous "Pesky" Pole, but everything to the left would simply not exist. Bring him around to the other



side of the stadium, facing toward home plate, and he will now see third base, the scoreboard, the famous outfield wall called the Green Monster, and the "monster seats" above it, that he previously neglected on that side of the field.

Not long after Bisiach led his patients through the Piazza experiment, he visited a lawyer who was also suffering from neglect. Facing the man, Bisiach asks him to describe his office while seated at his desk. No problem, the lawyer says, and proceeds to mention, in rich detail, his reading light, a painting, and every object on the right side of the room. Bisiach brings him around the other side of the desk and asks him to again describe the office. Now the lawyer describes his favorite piano, old tapestries, and other objects that were previously on his left. In the lawyer's world, space on the left side of his body has vanished. It has vanished so completely, he isn't even aware that it should be there. Meanwhile, his awareness of space on the right side has expanded.

Imagine how this feels. You wake up in the hospital and you're told you've had a stroke. You have lost awareness of the space on the left side of your body. Everything and anything that takes place in that space escapes your notice. You ignore people on the left side of the room, eat only the food on the right side of your plate, read only the right side of the newspaper page. If you shave, you just scrape or buzz the right side of your face. If you put on lipstick, you apply it to the right side of your mouth only. You neglect all sights, sounds, touches, and even smells on the left side of space.

Your neurologist gives you a pencil and paper with a horizontal line drawn on it and asks you to bisect the line with an *X*. You mark the mid-

### TREATMENTS FOR NEGLECT

Is there any treatment for these dreadful body delusions? Not much, unless you want to count putting ice-cold water in one ear or tingling the back of your neck with a vibrator.

Pretend you are a neglect patient. You are comfortably lying down on a couch with your head nestled to one side on a pillow. A doctor pours a few ounces of ice water into your left ear for one minute. This strongly stimulates a region in your inner ear, the semicircular canals, that contributes to your sense of balance. Your eyes gyrate involuntarily toward your left side as your subjective sense shifts toward the colder ear. You feel vertigo. And your sense of denial evaporates.

Or, while you are seated, looking straight ahead, the doctor applies the tip of a vibrator to the left side of the back of your neck. This alters the balance of left and right input from your vestibular system and throws your neck proprioception out of kilter. Your egocentric perception of space is upset. Your denial vanishes.

If the doctor puts ice water in your ear and vibrates your neck muscles, both on the same side, you get double the effect. But if he applies each stimulus on opposite sides, the effect is canceled out.

Both ice water and neck vibration work by biasing vestibular signals that are involved in spatial awareness, Dr. Edoardo Bisiach says. The effects are temporary. One patient who insisted that the left side of his body was evil and controlled by the devil was helped by the ice water treatment—for ten minutes.

Other treatments include training the visual system to attend to the neglected space, mental imagery training, wearing prisms to reorient space, and video feedback.



point way off to the right. Next he asks you to draw a daisy. You make a nice stem and fat round center. But you only draw petals on the right side. When you draw a clock, all the numbers, one through twelve, are bunched on the right side of its face.

But you are not blind. Your memory is fine. Your doctor can draw your attention to the left side of space by making you look more carefully: "Woo hoo, over here!" You'll say "Oh my!" as you see things you had neglected.

So what does all this have to do with peripersonal space? It turns out there are subtypes of neglect that provide elegant proof that your brain maintains a distinction between peripersonal space and the space beyond it, what is called extrapersonal space—the space that is farther away from your body, out past your fingertips. Some stroke patients show purely extrapersonal neglect. When asked to bisect a line past arm's reach using a laser pointer, they mark the midline far off to the right; but when asked to do the same thing with a pencil on a sheet of paper within their bubble of peripersonal space, they do it correctly. Their perceptions within peripersonal space are normal.

## Multisensory Connections

Scientists used to think of the parietal region—a region, as you'll recall from chapter 3, crammed with maps of your body and the space around it—as being a purely multisensory hub. In the old view, touch information flowed in through the primary touch cortex, visual information flowed in through the primary visual cortex, sound information flowed in through the primary auditory cortex. An orgy of cross-talk occurred, and the integrated information was then passed forward to the motor network, where it served as the basis for plans and actions.

But this is a vast oversimplification. It turns out the sensory maps of your parietal lobe are also de facto motor centers, with massive direct interlinkage to the frontal motor system. They don't simply pass information to the motor system, they participate directly in action. They actively transform vision, sound, touch, balance, and other sensory information into motor intentions and actual movements. And by the same token, the maps of the motor system play a fundamental role in interpreting the sensations from your body. Your parietal lobe is not purely sensory, and your frontal lobe is not purely motor. Physical sensation and action are best seen as a single sense that, like a coin, has two inseparable faces with different appearances. Consider the fact that people who have a body part paralyzed from damage to their primary motor map complain that the part also feels numb. Yet their sensory maps are all intact. So shouldn't they be able to feel normal sensations? They are not, because their sensory and motor maps, while spatially separate, are functionally one.

Multisensory cells and systems are all the rage in neuroscience these days. If you think about it, ordinary perception almost always involves multiple senses. It turns out the senses interact with one another profoundly. You will see something faster if it also makes a noise. A sudden touch on one hand can improve your vision near that hand. Seeing a friend speak across a crowded room can help you hear what she is saying. A picture of a snake or spider shown near your hand draws your attention to your hand far faster than, say, a picture of a rope or flower.

What you hear influences what you feel. In one dramatic example, called the parchment skin illusion, you rub your palms together while listening to different sounds. Higher frequencies make you feel as if your hands are rough. Lower frequencies give the impression of your hands being smooth, although nothing about your hands has changed. Similarly, all else being equal, an electric toothbrush will feel more pleasant and less rough on your gums and teeth when the overall sound level is reduced.

The next time you go to a movie theater, take a moment to consider that speech is not coming from the actors' lips. The sound of their voices is being piped into speakers far removed from their celluloid actions. Your brain creates the illusion of actors talking to one another, thanks to your multisensory cells. Of course, a badly dubbed foreign movie doesn't fool you a bit. It's just annoying.

If you have a computer handy, you can check out the McGurk effect (www.media.uio.no/personer/arntm/McGurk_english.html). In this auditory-visual illusion you will see a film clip of a person saying "da, da, da, da." But if you close your eyes, you will hear him really saying "ba, ba, ba, ba." Then if you mute the sound and just watch his lips, you will clearly see that he is saying "ga, ga, ga, ga." The effect is quite astonishing. It happens because your brain does its best to reconcile mismatching



information whenever it can. Bimodal vision-and-hearing cells chatter to one another about it and settle on the "da, da, da, da" interpretation.

Multisensory neurons are also at work when you recognize a type of music from its beat. Jessica Phillips-Silver, who recently earned her Ph.D. at McMaster University in Hamilton, Ontario, can demonstrate this by holding your hands and asking you to bounce, knees bent, in synchrony with her. In the background she plays an ambiguous rhythm with no strong accents. When the two of you bounce to every second beat, you will say you are hearing a march. But if you bounce on every third beat, you will say you are hearing a waltz. The movement of your upper body and vestibular activation are critical for the effect. What you feel with your body literally shapes what you hear, thanks to multisensory neurons.

## Probing the Bubble

So now you know that your brain maps the space around your body. But what is that space like? Is it a universal space, like one huge bubble enveloping your whole body? Or does it exist in segments, like Penfield's homunculi?

Two Princeton University neuroscientists, Michael Graziano and Charles Gross, helped find the answer in 1994 when they inserted electrodes into monkey brains and explored an important body map known as the premotor cortex. They were curious about some cells there that respond to both touch and vision, even though it is a "classic" motor area. When they touched a monkey on, say, the back of its hand, one or more of these cells in the map's hand region would fire. They also found that if they moved an object to within eight inches of the same spot—provided the monkey could see it, of course—the same cells would fire. In other words, these cells were mapping not just touch, but the nearby bubble of space around the body. When the seen object moves closer to the monkey's hand, the cells fire faster. When the object moves away, the cells slow down.

These cells focus your attention on the body part being approached and automatically prepare motor plans you can take in response, whether it's to move out of the way, reach out to intercept the thing, or stay still and let it touch you. Beyond that, such cells can even induce physical sensations before you actually get touched. As every parent knows, you only need to wiggle your fingers above your child's rib cage to elicit gales of laughter. It isn't uncommon for people to feel a tingling in their skin as something with emotional significance—whether a hypodermic needle or a lover's caress—approaches. This is the result of these touch-vision cells going into overdrive.

### WHY YOU CAN'T TICKLE YOURSELF

If cells that respond to touch and vision are so exquisitely sensitive, why can't you tickle yourself? You can wiggle all ten of your fingers and draw them close to your belly, yet you won't feel a flutter of anticipation or mirthful desire to pull away. You're a zombie when it comes to self-inflicted tickling.

The reason has to do with the fact that your brain is in the business of predicting your interactions with the world. When someone else tickles you, there is a sense of surprise and panic. Those other fingers feel like creepy crawlies, making you howl in protest. But they aren't dangerous creepy crawlies, and so you laugh with relief.

When your own fingers are involved, though, there is no surprise. You are in control. Your touch is familiar. You brain predicts the force, location, and speed of your movements and, this being ho-hum, cancels out or attenuates the sensation of self-touch.

Your brain carries out this feat by generating a carbon copy of your movements along with the actual motor command. The duplicate, called an efference copy, predicts the effects of your action, such as bringing your wiggly fingers toward your body. The predicted effect of the efference copy and the actual sensation from your motor command are compared. If there's a mismatch, you know the sensation came from the outside world (someone else's fingers). But if there is no mismatch, your prediction is deemed accurate. You do not feel a tickling sensation.

Incidentally, the reason you can't tickle yourself also explains why shoving matches tend to escalate into fistfights. In a study called "Two Eyes for an Eye: The Neuroscience of Force Escalation," people held out their left index finger, which was given a slight push by a motor. Then they were asked to match the force by pressing a force transducer that delivered a second push to the same finger.

People consistently pushed back harder with the transducer. Just as when you try to tickle yourself, your brain predicts the consequences of your movements and reduces the sensation. So when somebody hits you, you will hit back with greater force because your brain overestimates how hard you were hit. This is one way that street brawls spiral out of control. Or children take up the refrain: *But she hit me harder!*



Graziano and Gross's experiments reveal that each part of your body has its very own spatial map attached to it. When your arm moves, the bubble of personal space around your arm moves along with it. When your foot moves, its peripersonal space map moves, too. These maps are body-centered or ego-centered representations of visual space.

The same goes for sounds. You have multisensory cells that keep track of your body parts and the sounds around your body parts. When you sit in the dining room reading your paper and you hear a family member approaching from behind in the kitchen, the cells fire more rapidly. When the sounds grow fainter, the cells slow down. Blind people are aces at tracking sounds around their bodies using such cells.

## Seeing Auras

"Gloria" did not realize she was different from other people until shortly after her seventh birthday. She remembers thinking, Surely everyone sees colored auras around the heads and faces of people they know. It seemed perfectly natural to her to see the exact same colors associated with the face or spoken name of each person. It was not until Gloria was studying psychology a decade or so later that she discovered the oddity of her experiences.

How odd? When Gloria gets to know new people, they each acquire a colored aura. These halos can be blue, pink, purple, any color. If she knows two Alexes, each will have a different hue. Unlike the temporary auras associated with migraine headaches or certain forms of epilepsy, Gloria's auras are constant, invariable, distinct.

And so it was that Gloria in 2003 found herself in the laboratory of Dr. Jamie Ward, a psychologist at the University College of London, who figured out the cause of her bizarre perceptual world.

Gloria has emotion-color synesthesia. She genuinely sees auras, says Ward. She is not confabulating.

Synesthesia is a condition affecting up to five percent of the population in which normally separate sensations are joined. The awareness of one sense produces a response in one or more other senses. Thus tastes can have shapes. Numbers or letters have colors. Red has a smell. Voices have flavors. Certain sounds look like glass shards.

The Russian-born artist Wassily Kandinsky said that when he saw colors he also heard music, which is why he developed his style of abstract painting. Kandinsky was capturing music on canvas. Some synesthetes can "hear" his music by looking at his paintings.

Other people—more are turning up in Ward's lab all the time—have vision-touch synesthesia. When they see another person being touched, say, on the cheek, they feel it on their own cheek. If they see an actor being stabbed in the stomach during a movie, they feel a sensation in their own belly, but without pain, as if anesthetized. Like Gloria, they are astonished to learn that not everyone in the world has these experiences.

While all people link senses in a metaphorical way—"feelin' blue," "hot chick," "sour face"—synesthetes do so to a greater degree, Ward says. The reason may be that sensory areas of their brains are abnormally cross-wired. The infant brain is born with a huge number of redundant neural connections, which undergo a pruning process as the baby grows up and acquires skills. One theory of synesthesia is that sometimes some of these redundant connections remain in place, linking two or more senses at a lower level than normal. In effect, multisensory cells are created lower down in the sensory processing stream of a synesthete.

The mark of a true synesthete is that their perceptions do not change over time. Most experience their blended sensations in space; they see colored letters floating outside their body. For some, the colors appear only in the mind's eye. In any case, each synesthete is unique, based on individual brain wiring, as to which senses are crossed and to what degree.

When Ward tested Gloria in his laboratory, he first showed her eighty-three words and asked her to report any colors. She repeated the test a week later and again four months later. Her matches were consistent through time, a feat that would be very hard to fake. On another test, Gloria was slower in naming colors that conflicted with her automatic synesthesia. That is, if she always saw pink around a name and it was shown in blue, it would take her longer to read the name out loud. Finally, she did not see colors around unfamiliar names and faces but did see them around highly emotional words.

Gloria's emotion-color synesthesia raises a tantalizing question. Many people around the world, in all cultures, claim to see auras. Science has been forced to reject the idea that our bodies are surrounded by mystical energy fields, but could some people's experience of them be as real as



looking up into the sky and seeing a rainbow? Could auras be a natural construct of the parietal lobe?

One thing is certain, Ward says. People who claim it is possible to *learn* how to detect auras are not talking about synesthesia. Auras in the sense of a parietal blending of peripersonal space and color, or any other human sense, could never be taught. It is a natural product of a cross-wired brain. Gloria does not believe she has mystical powers. She does not think that what she does is remarkable. She just sees colors around people and cannot suppress it. But many other people who genuinely see auras are tempted by paranormal explanations. They attribute auras not to labile body maps but to supernatural forces, astral planes, leaky chakras, or energy fields of pure life force that emanate from all living things.

Scientists have never been able to detect with advanced instruments the kind of energy field that allegedly gives rise to auras in the paranormal sense. When the philosopher Sir John Eccles talked about a "field of psychons" as creating a unity of subjective experience, he did not base his claims on any experimental evidence or designs for empirical testing. When New Age gurus invoke the mysteries of quantum physics to explain the mysterious nature of energy fields and human consciousness, they are essentially explaining one mystery with another mystery.

But the fact that our body and peripersonal space maps are tremendously flexible provides a new scientific window into understanding many strange experiences. Jet fighter pilots sometimes say they enter an altered state when flying for long periods in monotonous conditions—uniform clouds, engine noise, vibrations. In this condition, they sometimes "leave" the aircraft and float outside the cockpit, looking back in at themselves. Eventually they force themselves to snap to and get back into their bodies. Mountaineers trekking at high altitude and sailors crossing the ocean alone also report losing their bodies.

Michael Murphy tells anecdotes of transcendent experiences in sports in his book *In the Zone.* Athletes leave their bodies or see other bodies change shape on the playing field. A well-known distance swimmer described how, whenever his physical body was exhausted during a competition, he would relax by floating overhead while his body continued to swim, until he felt refreshed, at which point he would reenter his body. Another swimmer says he can see the entire pool from a larger raised-up perspective and anticipate the moves of the other swimmers.

You can have weird experiences falling into and waking up from sleep. Have you ever awoken to the feeling of an ominous presence in the darkness pressing down on your body? Odds are it wasn't a dream. People have been reporting these encounters for millennia, which surely lent credence to the existence of otherworldly beings like ghosts and incubi. Or have you ever felt yourself leave your body as you fall asleep? Both phenomena, which are surprisingly common, are created when your brain shifts its state of arousal in the transition from sleep to wakefulness or vice versa. Every night while you're dreaming, your body is totally paralyzed from the neck down via inhibitory circuits in your brain stem (failures of this system are involved in sleep violence and sleepwalking). Your brain does this to keep your body from jumping out of bed and acting out your dreams. But sometimes you stay paralyzed after you have awoken, and your body mandala's best-fit interpretation is that a crushing weight is pinning you down. It can be terrifying. But rest assured, when it ends it's because your brain has reestablished the connection with your muscles, not because the incubus has vanished back to Hell.

When people enter deep meditation or trance, they say that their bodies and minds expand out into space. Body awareness fades, and they are left with a unitary yet diffused and nonlocalized sense of themselves. Along with it come feelings of joy, clarity, and empathy. When Buddhist lamas meditate in brain scanners, activity in their parietal lobes plummets. It can't be a coincidence that the dissolution of the bodily self accompanies the shutting down of the body and space maps that create it.

## Shadowy Illusory Persons

Ever had the creepy feeling, while you are wide awake, that another person is lurking behind your back, only when you turn around, no one is there? What about an out-of-body experience? Have you ever felt yourself floating up near the ceiling, looking down at your corporeal self?

Such experiences, which may be more common than is generally acknowledged, are almost always explained in terms of paranormal forces—an encounter with ghosts or crossing to another realm of reality.

But according to Olaf Blanke, a neurologist at the Ecole Polytechnique Fédérale de Lausanne in Switzerland, the feeling of an illusory shadow person or the sensation of leaving one's body can be induced, in mentally healthy persons, by delivering a mild electric current to specific spots in the brain.



A zap to one spot, the right angular gyrus, recently gave one woman the palpable sensation that she was hanging from the ceiling, looking down at her body. Current to the left angular gyrus gave another woman the uncanny feeling that a shadowy person was behind her back and that he was intent on interfering with her actions.

Both women were being evaluated for epilepsy surgery at University Hospital in Geneva, Switzerland. Physicians implanted dozens of electrodes directly into their brains to pinpoint the abnormal tissue causing their seizures and to identify adjacent areas involved in language, hearing, or other essential functions, so as not to excise them inadvertently. When each electrode activated a different patch of brain tissue, the women said what, if anything, they experienced.

Despite their epilepsy, both women had normal psychiatric histories, Blanke said. The women were stunned by the bizarre nature of their experiences.

One patient was a twenty-two-year-old pharmacy student who had electrodes implanted into the left side of her brain in 2004. "We were checking language areas," Blanke said, when the woman turned her head to the right. That made no sense because the electrode was nowhere near areas involved in movement control. It was in a multisensory area where the parietal and temporal lobes meet.

Blanke applied more current. Again, the woman turned her head to the right.

"Why are you doing this?" he asked.

The woman replied that she had the weird sensation that another person was lying directly beneath her body on the bed. It was not in the mattress, but rather stretched out behind. It felt like a "shadow" that did not speak or move; it was young, more like a man than a woman, and it wanted to interfere with her.

When Blanke turned off the current, the woman stopped looking to the right. The strange presence went away. Each time he reapplied the current, she turned her head to try and see it.

The woman sat up, leaned forward, and hugged her knees. Now when the current flowed, she noted that the "man" was also sitting and that he was clasping her in his arms. She said it felt unpleasant. When she held a card in her right hand, the person tried to take it from her. "He doesn't want me to read," she said.

Because the illusory person closely mimicked the woman's body posture and position, Blanke concluded that she was experiencing a perception of her own body—a felt double or doppelganger. She did not recognize that the person was an illusion of her own body.

## Out-of-Body Experiences

"Heidi" suddenly felt herself lifted out of her body. Floating near the ceiling, she looked down, aghast. Seated around her real body were three people, one of whom held an electrode over the exposed right side of her brain. Blanke was applying small amounts of current to different areas of her cortex to find the locus of her seizures.

When Blanke stimulated Heidi's right angular gyrus, she felt herself rise up, as if she were the gauzy apparition in a Tim Burton movie.

"I am at the ceiling," she exclaimed. "I am looking down at my legs." This had never happened before. She was stunned.

"What?" Blanke was equally astonished, and removed the electrode.

"Wait," said Heidi. "I'm back on the table now. What happened?"

"I'm not sure," he said, "Let's try again."

Blanke stimulated the same spot in Heidi's brain for another two seconds. Because the electrode is silent, she had no way of knowing when to expect anything. But while the current flowed, she found herself back at the ceiling, outside her body, floating, with her ghostly legs dangling below her ghostly self. She gasped again.

"What do you see?" Blanke asked Heidi-on-high.

"My back is touching the ceiling. My legs are hanging down a little. I can see the three of you."

"Do you have arms?"

"I'm not so sure about my arms," Heidi said. "But I have a head and a body. I see the bed and the side table. I'm lighter than usual, not moving."

Blanke was fascinated. From the ceiling Heidi saw only the lower part of her body. But why would she tell him that? Why not her whole body? Then it occurred to him to consider the position of her real body—propped up in bed, arms straight down at her sides. From her vantage



near the ceiling, she saw those same body parts—feet, pajamas, trunk, and legs—that she would see looking at herself from the bed.

Blanke decided that Heidi was not making this up. Given that, he struggled to find an explanation. "Try looking at your limbs," he said, applying the current for the third time. "Tell me what you see."

Again she gasped. Now, when she looked at her outstretched arms, the left arm seemed to shorten to half its normal size. As in a Tom and Jerry cartoon, it grew shorter and shorter, and then, when the current stopped, it popped back out to its normal size.

Heidi had never read a neurology textbook, Blanke says, and had no way of knowing that stimulation to her right brain would affect the left side of her body, specifically her left arm.

Oddly, though, both legs appeared to shorten by a third during the stimulation. Blanke decided to bend her legs in the bed and see what would happen.

Again the current flowed; this time Heidi screamed. Both legs seemed to fly up and were about to hit her in the face, even though her real legs remained motionless. When she closed her eyes, she had the sensation of doing sit-ups, with her upper body approaching her legs.

Heidi's uncanny adventure, which took place in December 2000, is the first recorded case of an out-of-body experience induced by electrical stimulation of the brain. As long as her body maps were synchronous, her experience and behavior were fluent, holistic, and integrated. But when Heidi's maps went briefly out of sync, her felt position in space and her seen position in space did not match. Her mind cast about for the best-fit way to turn her confusion into a coherent experience, and concluded that she must be floating up and away with a view downward.

But what if you have an out-of-body experience without someone zapping your right angular gyrus? Plenty of people report briefly perceiving the world from a location outside their bodies, often during a near-death experience. One explanation for the phenomenon is alterations in blood flow. Large arteries converge near the angular gyrus inside your brain. If anything constricts the flow of blood to that area, your felt body sense can become disoriented. You might get the feeling that you are floating above an operating table or the scene of a car accident. At the same time, your field of vision might have what is called a scotoma—a big blank spot, like a black splotch at the bottom of a well—that your brain fills in with images of what it expects or would like to see.

## Peripersonal Space in Culture

In the late 1990s, Richard Nisbett, a professor of social psychology at the University of Michigan, met a Chinese student, Kaiping Peng, who told him, "You know, the difference between you and me is that I think the world is a circle and you think it's a line."

Nisbett was startled. He strongly believed that all human groups perceive and reason in the same way, that people everywhere rely on the same tools for perception, memory, causal analysis, categorization, and inference. How could one culture think in circles, another in lines?

Unfazed, Peng continued, "We Chinese believe in constant change, but with things always moving back to some prior state. We pay attention to a wide range of events, we search for relationships between things, and we think you can't understand the part without understanding the whole. You Westerners live in a simpler, more deterministic world. You focus on salient objects or people instead of the larger picture. You even think you can control events because you know the rules that govern the behavior of objects."

Nisbett was intrigued. Is it possible, he wondered, that your culture shapes not only your speech and attitudes and judgments but even your basic patterns of perception? Is it possible that how you experience your senses, your body, and the space around your body is largely defined by your culture? After all, your brain is constructed by an interplay of genes and experience, with culture providing much of the input. So it was worth investigating.

Nisbett and Peng, now a professor at the University of California at Berkeley, have conducted numerous experiments showing the extent to which culture shapes perception. For example, when American students are shown an animated underwater scene, they describe a big fish swimming among smaller fish. Japanese students looking at the same scene describe the background and the scene in general and pay less attention to the big fish.

This result is intriguing, but the difference might stem from how people from each culture use language; it does not necessarily prove that they perceive the same scene differently. So in another experiment the scientists have their subjects look at pictures while their gaze is tracked with a device called an eye tracker. What they find is pretty sensational. When Americans look at a photograph of a tiger in a jungle, for example, their eyes fixate first and primarily on the animal. When East Asians look at the photograph, their eyes fixate on objects in the background with occasional fixations on the big cat itself. In other words, Americans focus their attention on a central object, while East Asians take in the whole scene. And this difference shows up at the level of how their eyes scan an image, which is a function carried out well below the level of conscious control.



So at least in some areas, you do perceive the world differently depending on what culture you grew up in. How you allocate your visual attention, how you use your eyes to parse a visual scene, varies as a function of culture. This example is of visual mapping, not body mapping, but it is a potent illustration of how deeply culture can penetrate into faculties we generally assume are hardwired into us as a species. Significant hardwiring is there, to be sure, but it can be molded by early experience more than we tend to appreciate. You are a child of plasticity as writ by your culture. How you use and conceive of your body is no different.

A new academic discipline called sensory anthropology focuses on how cultures stress different ways of knowing through the body maps and the senses. Notions of sight, sound, touch, taste, smell, balance, proprioception, and personal space are all conceived or even mapped differently in people from various cultures. Culture deeply modulates perception.

The Anlo of Ghana hold that balance is a powerful sense, important in the way that vision is to Westerners. Their language contains more than fifty terms for different kinesthetic styles, and each way of walking says something about a person's moral character. The worst thing that can happen to an Anlo is loss of the vestibular sense, because balance is the most important sense of all. Personal space is defined by balance. And dance is an essential part of life. During ritual dances they can independently move eight or nine parts of their bodies.

The Paluti of Papua New Guinea believe personal space is defined by sound. The Ongee of the Andaman Islands believe personal space is defined by smell. The Dogon of West Africa speak of "hearing a smell."

They classify words by smell: Good speech smells sweet, bad or impetuous speech smells rotten—indeed, the "mouth too ready to speak" is likened to the rectum.

Americans protect the bubble of space around their bodies and think of it as a comfort zone, which other people may not enter uninvited. Thus the cultural anthropologist Edward T. Hall divides space around the body into zones, like concentric sectors on a dartboard, with you as the bull's-eye, and argues that these zones have different dimensions in different cultures. Mediterranean and Asian cultures have relatively closer personal space zones, while Northern Europeans have more distant zones. In particular, Hall says, Americans have four zones. Intimate space extends six to eighteen inches from your body. It is the space you use for embracing a lover, comforting a child, or whispering. Personal space extends from eighteen inches to four feet from your body—about the same volume as your peripersonal space (coincidence?). It is the distance you adopt when talking to a friend. Social space, four to twelve feet from your body, is used for talking to acquaintances, strangers, or your boss. And when you address an assembled group, you will stand twelve or more feet away from your audience to create public space.

In each social context, Hall says, you choose your comfort zone and broadcast it to others with body language—with gestures, eye contact, posture, facial expression, and how you listen. If your space is violated you may feel uncomfortable, threatened, or upset. Hall first observed this when he worked for the State Department in the 1950s and watched an American diplomat back into a wall while talking to an Arab diplomat.

On a subway, you make yourself as small as possible and try to avoid body contact with strangers. On an elevator, you avoid eye contact, emotion-laden expressions, and loud speech. But at a sporting event or music concert, you may feel intimate with the crowd and bask in the collective sensorium.

## A Sense of Where You Are

It was positively spooky the way Bill Bradley played basketball. He seemed to know the location, velocity, and direction of every player on the court at every given moment and effortlessly threw the ball to where he expected teammates to be. Playing for Princeton and later for the



Knicks, he was always a little bit ahead of everyone on the court, knowing where there was an open shot, when to jump for it, when to pass, when to feint. With his back to the hoop, he could toss the ball over his shoulder and sink the shot every time.

As Bradley once told the writer John McPhee, "When you have played ball for a while, you don't need to look at the basket when you are close in like this. You develop a sense of where you are."

Much has been written about the makings of superstar athletes. As noted earlier, the most important fact seems to be that they practice harder and longer than most other elite athletes. Sure, they are born with physical advantages—fast-twitch muscles (the kind of muscle you rely on in sprinting and boxing), long limbs, high anabolic thresholds, extraordinary hand-eye coordination, lightning-fast reflexes, and the like—but so are other elite players. The best of the best simply work at it more.

All that practice early in life leads to deeply ingrained motor patterns that help the athlete excel. Bradley shifts his feet in the same patterns tens of thousands of times until the moves are unconscious. Brazilian soccer superstar Ronaldinho uses his eye-foot coordination to encode the position of the soccer ball relative to his head, knee, and foot. Red Sox pitcher Daisuke "Dice-K" Matsuzaka can control precisely how and where a variety of pitches, including his ninety-six-mile-an-hour fastball, whiz through the strike zone.

Top athletes also tend to have superb vision. Hitters see the baseball as it leaves the pitcher's hand. A quarterback can pick out receivers on the fly. Bradley has a reputation for seeing out the back of his head. His peripheral vision is off the charts. He could stare at the floor and see a pass coming in from way over his head. According to McPhee, he could look at everything, focusing on nothing, until the last moment of commitment.

But there is one trait among great athletes, especially those whose game is played on open courts or fields (like soccer, basketball, American football, rugby, lacrosse, and hockey), that has not been described on ESPN or elsewhere. It explains why some people have an extraordinary sense of where their bodies are located in space, as well as the fast-moving bodies of all their teammates and opponents. Namely, the very best athletes have really great "place cells." And maybe even more important, they have spectacular "grid cells."

Place cells and grid cells are space-mapping neurons linked to a memory-forming region called the hippocampus. The hippocampus is evolutionarily much older than the cortex. So despite the amazing power and flexibility of our cortical space and body maps, this ancient system of place and grid cells is still very much with us—you could say it was "grandfathered in." Instead of mapping personal space from an egocentric point of view, as your parietal and premotor circuits do, place cells and grid cells are what scientists call geocentric.

They are different: Place cells are context-sensitive, while grid cells are context-independent. Place cells map the space around your body in terms of whatever environment you happen to be in—a room, a city street, a basketball court. They tell you where you are relative to the specific landmarks around you. They are what enable you to plan your route through a restaurant full of tables, keep track of where you are in a Wal-Mart, and help you decide where to go next while you're picking your way through a crowded room.

Grid cells are similar, but they do not attune themselves to landmarks. They map space independently from your environment. They are your dead reckoning cells. The point two feet in front of your nose is the point two feet in front of your nose regardless of whether you're in a cocktail bar or lying in bed or standing in the middle of a featureless plain.

Place cells were discovered in 1971 when two neuroscientists, John O'Keefe and John Dostrovsky, implanted electrodes into the brains of mice in an effort to study memory. Their target was the hippocampus. As the animals moved around their familiar enclosure, the scientists noticed that some cells fired when a mouse was in the southwest region of its home enclosure. Other cells fired when the animal moved to the northwest region. The same thing happened in different areas of the east half of the enclosure. In fact, it was possible to tell where an animal was inside its enclosure simply by looking at which cells were active. Each time an animal moved, a different population of hippocampal cells marked its place in space. If the animal moved back to the same location, the same cells became active again.

The researchers named these cells "place cells." They went on to learn that a rodent has many thousands of place cells, each tuned to a different region of space, called a place field. Even though there are only thousands of cells, a rat can learn many more locations than it has individual place cells through the power of combinatorics—the same principle that allows ten buttons on a telephone to represent all the phone numbers of an entire nation. The place cells can be active in millions of combinations to map all place fields in a given environment, whether it's a cage, a ship's hold, a barn, a wide-open pasture, or any other place a rodent might find itself. Moreover, some place cells fire in response to edges in an environment, like walls. And when a mouse or rat enters a new environment, a new place map is formed in minutes.



You have place cells too. When you walk into your kitchen, certain place cells fire when you are standing in front of your refrigerator. As you move toward the sink, a different set of place cells will mark your new position in the room. If you walk into your dining room or living room, another combination of place cells will mark your spot in space.

Your place cells have, in a sense, memorized the contents of each room, helping you know where you are in each zone of space. Thus in the dark you can move around any room in your house or apartment and not bump into things because your place cells have mapped where each piece of furniture is located, where the doorknobs are, and how far the light switch is from the doorframe. You have an internal map of where objects are located in relation to one another and in relation to your body as you move through space. Your place cells also take information from other parts of your self-motion system, including cells that keep track of where your head is turned, and constantly help update you about your balance and your body schema.

Spin yourself around a few times in the middle of a room. Then try to reach a door. You won't know which direction to go until you locate an object you recognize. Only with this cue can you work out where the door is located. This means that your place fields are calibrated according to fixed reference points—sofa, chair, table, window, door—that do not usually change. If you move your furniture around, your place fields reconfigure to update your map.

When you enter a place you've never been before—say, a ballroom—new combinations of place cells rapidly come to map the new space. Just like for the rat in its enclosure, one group of cells comes to represent the foyer, another set represents the area around the buffet table, still another set represents the dance floor under the chandelier. Every time you return to any of these regions, the same group of cells fires as a unit to give you a sense of where you are.

Incidentally, place cells explain why some people always seem to know which way is east, west, south, or north. You ask them, "Which direction are you facing," and they are usually right. This is because they have place cells that always fire when they face south, others for north, and others for east and west. If you're confused about cardinal directions, you'll always be confused, because your place cells are confused.

Grid cells, first described in 2005, map space differently. They supply you with your sense of dead reckoning, your ability to navigate without landmarks. The scientists who found them, in Edvard Moser's research group at the Norwegian University of Science and Technology in Trondheim, say it makes sense that the brain would have some way of keeping track of the body in space independently of details in the environment. There should be some way to calculate where you are based solely on your own movements, not on where the furniture is placed.

Grid cells do the job. Located just one step higher in the cortical hierarchy from place cells, in a region called the entorhinal cortex, each grid cell acts as though the surface of your local environment had a triangular grid painted all over it. (Grid cells have only been demonstrated thus far in rodents, but scientists who study navigation are extremely confident that humans have them, too.) A grid cell is active when you are at the vertex of any of the triangles in the field in front of you but inactive for locations between the vertices. The grid persists like graph paper spread as far as you can see, or like the Holodeck on *Star Trek* before scenes are projected onto it. When you move through space, grid cells mark your position independent of context. Place cells "say" *I am in the store, I am in my house, I am in a strange plaza.* Grid cells keep track of where you are in all contexts, in all kinds of places, as if they were a property of the environment itself and not cells in your brain.

"Grid cells came as a big surprise," Moser says, "but now that we have seen them, they make sense. I strongly believe you are born with them or they develop very early in life. There are many reasons to believe that place cells are sums of grid cells," he adds, but that research is just getting under way.

Nevertheless, Moser, when asked, is willing to venture a guess that



great athletes have highly developed place cells and grid cells. Yes, they need fast reflexes, trained muscles, great eyesight, and developed brain networks to compare different trajectories; but when Ronaldinho looks down a soccer field, he is mapping the entire field in his brain. He has an effortless, innate sense of where he is in space and time, thanks to how well his brain maps that space. Every time he takes a step, an entire new geometry of action is created within his brain. In ten seconds, Ronaldinho will see at least one hundred alternatives and will make choices that draw on his body mandala, place cells, and grid cells.

## Using and Blending Personal Space

The Himba imagine that a bubble of personal space literally surrounds your body, the same way a magnetic field surrounds an atom or a planet. While science can't quite yet sign on to this interpretation, the evidence makes clear that your peripersonal space bubble is, psychologically speaking, as real as anything. This space is part of you, no less than your limbs and head. Without it you would still have a body, but your isolation from the physical and social world would be profound.

For the next few days, try thinking about your personal space as you move about and do your normal activities. Take a walk by yourself, go for a run, sit at your desk, cook a meal. Try to appreciate the myriad ways that you use the space unconsciously.

If you are a solo dance performer, your personal space is your medium for expression. By extending the lines of your body into space, by arching and bending, you are setting your space into motion, shaping it for others to admire. Indeed, you can make a small room seem enormous by the quality of your movements. You know when there is or is not enough room to make certain movements based on your body maps. You know how to use shadows to change perceptions of your personal space. Professional dancers say that dance is a spatial extension of the body that reaches out and touches other bodies. It involves "leaking into space," unveiling the invisible.

The martial art tai chi is a graceful and elegant way to explore your personal space. Learning the structured movements or forms is like learning a foreign language, only it is the language of body and space in motion. The goal is total unification of mind, body, and intention. Barbara

Davis, editor of the *Taijiquan Journal*, says that some students have difficulty finding the boundaries of their personal space, some are too rigid about holding their space, and others are all too ready to "fall down and be a doormat." To learn tai chi, or any martial art, Davis says you have to retrain your body and your relationship with your personal space.

When you're threading your way through a subway station or standing in a crowded elevator, your personal space rubs against and slides past the space of others. But there are other conditions in which personal spaces can merge. As you think about your personal space, see if you feel anything when you come into close contact with friends and family. The Himba say they are never alone because their space maps fuse with others' throughout the day. Do you feel blended personal space? Do you sense the creation of "we-centric" space?

If you are a mom or dad, hold your child close and think about your body maps. When your child sits on your lap, are you palpably sensing each other in shared space? It is likely, but not yet proved, that your brain contains spatial mapping cells that specialize in "affiliative behavior," which is a clinical term for cooperation and intimacy. When you hug someone you love, these cells, dedicated to making you feel safe in the envelope of shared personal space, are likely buzzing.

The reason to think there might be such "hug" cells is that neuroscientists have found "flinch" cells in the monkey brain used for thwarting threats within personal space. Flinch cells fire when objects approach the face or body. The monkey will squint and blink, lift its upper lip, turn its head away, shrug its shoulders, or lift a hand into the space near its head.

Michael Graziano, the Princeton University neuroscientist who discovered flinch cells, says, "Your brain needs a system to keep you from bumping into furniture and staying a healthy distance from a cliff, to help you run through a twiggy forest without poking out your eye, brush away an insect, reach safely around a prickly object, or sit at a desk without bruising your arms and elbows as you work. Your life would be impossible without protective mechanisms operating out of consciousness."

So might you also need a system for allowing others to come close inside your mapped body spaces. Life is full of joint actions in which personal space is shared and movements are coordinated—a fast pass in basketball, a piano duet, martial arts combat, acrobats, a cheek-to-cheek dance, dressing a child, carrying a heavy piece of furniture with another person.



In one experiment of joint action, pairs of people were asked to lift wooden planks off a conveyor belt. You could only touch the planks, which varied in length, at the ends. Thus you could carry short planks by yourself, but at some point you would have to seek help from the other person. This transition point is interesting because it reveals how you take your partner's action capabilities (remember affordances?) into account. If both of you have long arms, you'll wait longer than a pair that has shorter arms. You will also adjust your action to the exact arm length of your partner.

When two people juggle together, they plan and execute their actions in relation to what they predict the other person will do—in shared space mapped by each brain. In fencing, each person controls personal space via fancy footwork. When one person penetrates the personal space of the other, the attack is on.

Horses and riders blend personal space. Good riders know how to give up their center to a cantering horse while the horse gives up its center to the rider. With each step, the horse and rider react to mutual feedback of blended personal space. The horse gives cues and the rider gives cues. Novice riders tense up because they do not know how to respond to the horse's space and body maps in motion. Horses sense stiffness in inexperienced riders and may, if they're feeling ornery, try to toss them off their back.

In traditions of healing touch—shamanic healing, energy healing, universal life energy, Reiki, and scores of other healing practices from around the world—practitioners use a combination of visual imagery, motor imagery, and gestures to merge their own peripersonal space sense with that of their patients. It might involve laying on hands, manipulating the vitalistic "energy fields" believed to suffuse and surround the body, or passing magnets or crystals over special body points called chakras. The experience, both for the healers and their patients, is quite real: Both can often literally feel the shifting of the energetic currents or fields they believe are there.

The scientific method has never been able to confirm that chi flows or other mystical vital energies are real and present in the mind and body.

Yet the experiences of these things are so palpable for so many people that it would be a cop-out to dismiss them out of hand as "nothing more than" wishful thinking. Perhaps science, having banished these energies from its account of reality, can nonetheless explain the sensory awareness that people have of them. The brain's touch, movement, and peripersonal space maps go far in explaining many key elements of these beliefs and experiences.

Peripersonal space is physically, literally mapped in your brain's parietal and frontal lobes. So are your motor intentions within that space. Your sense of owning this space is so real and encompassing that you may be tempted to feel that you can direct or otherwise manipulate the space as if it had substance or intrinsic energy. This is because your experience is of your brain's representation of that space, rather than of the space itself. In your higher-order action and peripersonal space maps, your body mandala is constantly blending the objective with the subjective. The objective constitutes your physical movements and the feedback sensations you receive by interacting with the things around you. The subjective constitutes your motor plans, both real and potential; the possibilities for action, including affordances, which you subconsciously perceive and automatically simulate; and the actions of other people, which you also simulate in your body mandala.

Because of this seamless subjective-objective blending, it is easy to perceive the subjective component as having objective reality. And because the many maps of the body mandala share information back and forth, these beliefs can even percolate down to the primary touch map and generate phantom sensations—tingles and gentle forces—that the mind interprets as perceptions. This establishes a feedback loop, reinforcing the belief in mystical energy fields all the more. Have you ever had a Reiki practitioner hold her hands over your chest? Even skeptics are likely to feel an anticipatory tingle. Have you ever played with a Ouija board? The forces you seem to feel on the pointer are coming from your and your partner's muscles—but the illusion of outside agency is incredibly convincing.

The idea that peripersonal space can be harnessed to treat and cure human ills is widely accepted in cultures around the world. The fact that metaphysical healing practices endure says something important about their efficacy, for indeed they do very often work. But the reason they



work is not, in the scientific account at least, metaphysical. Rather, they work because people expect them to work, and because the body mandala is flexible and creative. You have already seen the power of expectation and belief in creating your reality. In the same way, expectation and belief are primary engines in health and disease. Placebos are a potent form of medicine. For people who are drawn to spiritual beliefs, healing touch works wonders.

Musicians strive for joint action that transcends each individual. Watch your favorite band in a live jam session. And have you ever gone to a reggae or rock concert where thousands of people move in unison to the music? If you stand back and watch the crowd, you may get a vivid sense of One Big Body Map. Seriously, try it. The same goes for being at a gospel service or for when a batter hits a home run in a baseball stadium. As the crowd leaps to its feet, you can feel the unity of the experience not just in your eyes and ears but in your expanded body map.

And lovers? Have you ever noticed the way lovers hold hands, with fingers interlaced? Children and friends hold hands, but with palms touching. By intertwining their hands, are lovers mingling their body maps? It seems obvious that lovemaking is the ultimate instance of blended personal space. The act brings two bodies and their bubbles of space into one body, one space. They are a unit. Some might say it is entanglement, as when subatomic particles have partners, but you don't need to invoke the mysteries of quantum mechanics to explain the phenomenon.