When it comes to therapy for stroke patients, sometimes treating the wrong hand is exactly right

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Professor of kinesiology and neurology Robert Sainburg at his lab at Penn State Health in Hershey. Also an occupational therapist, Sainburg is organizing a group of early-career OT researchers to raise awareness of how basic neuroscience can inform OT practice. Credit: Penn State Health

A tiny clot moves up through the carotid artery, into a branch that leads to the right half of your brain. The vessel narrows and branches again; the clot snags on the vessel wall, blocking the flow of blood to parts of the right cerebral cortex. Stroke.

By the time doctors dissolve the clot and restore circulation to that part of your brain, thousands of nerve cells will have died. The functions they controlled, such as movement of the left arm and hand, will be severely impaired, perhaps forever. Within days, you will start getting occupational therapy to help your clenched left hand relax and regain what function it can, and to learn how to do routine tasks like dressing yourself with just your healthy right hand.

That's been the standard therapeutic approach for decades, but it misses something important, says Penn State neuroscientist Bob Sainburg. Your right hand, the one on the same side as the brain damage, is not quite normal. It's a little clumsy, a bit off in its movements. Compared with the left, it is your "good" hand, says Sainburg. "But it's a bad good hand."

Not just a neuroscientist

Sainburg wasn't the first person to note that the "good" hand of stroke patients often doesn't move well, but he was the first to try to answer the million-dollar question: If each hand is controlled by the opposite side of the brain, as clinicians believed, why is a stroke patient's "good" hand often so bad at certain tasks?

He comes at the question from an unusual perspective. He's not just a neuroscientist; he's also an occupational therapist (OT), adept at evaluating movement and devising ways to improve it. Starting out in the 1980s as a pediatric OT, "I worked with a lot of kids with cerebral palsy," he says. "Just like with stroke, you feel a bit powerless in terms of how to facilitate better movement. Brain damage is very resistant to recovery. And so I was very frustrated."

In right-handers, the left hand is just as adept as the right, but at different things. When cutting a bagel, for instance, the right hand is good at wielding the knife and the left hand is good at holding the bagel still. Studies of handedness led Bob Sainburg to a new approach to therapy for stroke patients. Credit: Patrick Mansell / Penn State

He soon found he could not keep doing the standard therapies, which sometimes helped the kids but were not based on a deep understanding of how the brain controls movement. "Some therapists are comfortable at that level," he says. "I wasn't. I needed to understand the mechanisms before starting to do an intervention."

Sainburg returned to grad school to study the basic neurobiology of motor control. After finishing his Ph.D. and post-doctoral training, he began to focus on handedness, the different abilities of the left and right hands. He reasoned that if the greater skill of a person's dominant hand is not simply due to practice—if it stems from differences in the two sides of the brain—then handedness might offer a window into how the brain controls movement. He began by exploring the possibility that motor control in people is lateralized.

"Lateralization means one side of your brain does things that the other side doesn't," he says. "Where it really stands out is with language. If you have a lesion in specific areas on the left side of your brain, you will have an aphasia, which means you can't call up words and phrases, and you can't figure out the sequence of words. If you have a lesion in specific areas of the right hemisphere, then you will be able to get words, you will be able to put them in the right sequence, but you won't be able to interpret and express non-verbal aspects of language." For example, you wouldn't be to tell the difference between a polite request to "Come here" and an angry demand to "COME HERE!"

There was reason to think the neural control of movement might show a similar kind of segregation. At the time, researchers elsewhere were discovering that many motor behaviors are lateralized in a variety of animals. Chickens tend to keep a lookout for predators with the left eye and search the ground for edible tidbits with the right. Schooling fish tend to dart to the right to flee danger, and tend to be better at detecting danger coming from their left.

Left brain, right brain

Sainburg set out to learn exactly what each hand does well and not so well. He invented a virtual-reality apparatus, now called the Kinereach, to test the ability of each hand to do tasks requiring specific skills. A shuffleboard game in which a hand makes a cursor strike a digital puck toward a target tests that hand's ability to aim a movement and use the necessary speed and force. A reaching game in which the hand encounters resistance along the way tests how well the hand adapts to changing conditions in the environment. Sensors on the arm and hand record the movements, and Sainburg developed software that lets him analyze each movement in detail.

Sainburg's lab manager, Candice Maenza, helps volunteer Mike Boyer settle into his seat at the Kinereach before he demonstrates how the apparatus works. Several years ago, Boyer had a stroke on the left side of his brain, leaving his right hand with minimal function. In Sainburg's earlier American Heart

Association study, Boyer received training of his "good" left hand, therapy he said was the best he'd had since the stroke. Credit: Penn State Health

All the participants in his studies were healthy, and they were all right-handed; lefties comprise only about 10 percent of the population, making it hard to find enough for a study. More importantly, they have been shown to be very different from one another in terms of differences in right and left hand coordination. Because of this variability, lefties are not a good group for studies on how the brain is lateralized for motor control.

After dozens of experiments, a clear picture began to emerge: The left hand is just as adept as the dominant right hand, but at different things. The right hand is good at aiming a movement accurately and executing it efficiently, but it doesn't adapt well to changing conditions. The left hand is not as good at the initial aim, but is very good at countering outside forces, responding to changes in stiffness or friction, and homing in on a target accurately.

It looked like the motor centers on the two sides of the brain have different command responsibilities. The right hemisphere stabilizes the hand and enables it to adapt to changing conditions, and the left hemisphere directs efficient, precise movements. Each hand is controlled primarily by the opposite side of the brain, but the division of labor is not complete. Each hand has some ability to do what the other is expert at, suggesting that both hands receive guidance from both sides of the brain.

To really nail that down, Sainburg needed a way to test the hands of people who had lost function in motor-related areas on one side. That's what led him to work with stroke patients.

He recruited volunteers who had suffered an ischemic (blood clot) stroke in one side of the brain and now had severe disability of the opposite arm and hand. He tested how well their other hand, the "good" hand, did at various tasks. Conventional wisdom said the good hand would be unaffected by the stroke, but Sainburg's results showed otherwise. In patients with right-brain damage, their right hand did badly on tests of how accurately it could stabilize at the end of a reaching movement ("badly" meaning substantially worse than in subjects who had not had a stroke). In patients with left-brain damage, the left hand did badly on tests of how well it initiated a movement and set a trajectory.

In other words, damage on one side of the brain did affect the hand on the same side, depriving it of guidance needed for well-coordinated movement. Since a lesion in one side of the brain affected both hands, each side of the brain must normally provide information and instruction to both hands, not only the hand on the opposite side of the body.

One exercise done by study volunteer Mike Boyer is to pick up cups and place them in the appropriate stack based on their color. Credit: Penn State Health

Why are our systems made this way? Why not have both sides equally capable of performing every function? Sainburg thinks there's a strong evolutionary advantage to segregating the functions. In his experiments with the Kinereach, healthy participants took about twice as long to initiate a task when they were given the option of using either hand than when they were told which hand to use. "In evolutionarily important conditions, that extra time could really matter," he says. "I think it's a huge advantage to not have to make decisions about which hand to use. If you can have some asymmetry, so that certain tasks automatically go to one side and others automatically go to the other side, maybe that's more advantageous than we tend to think."

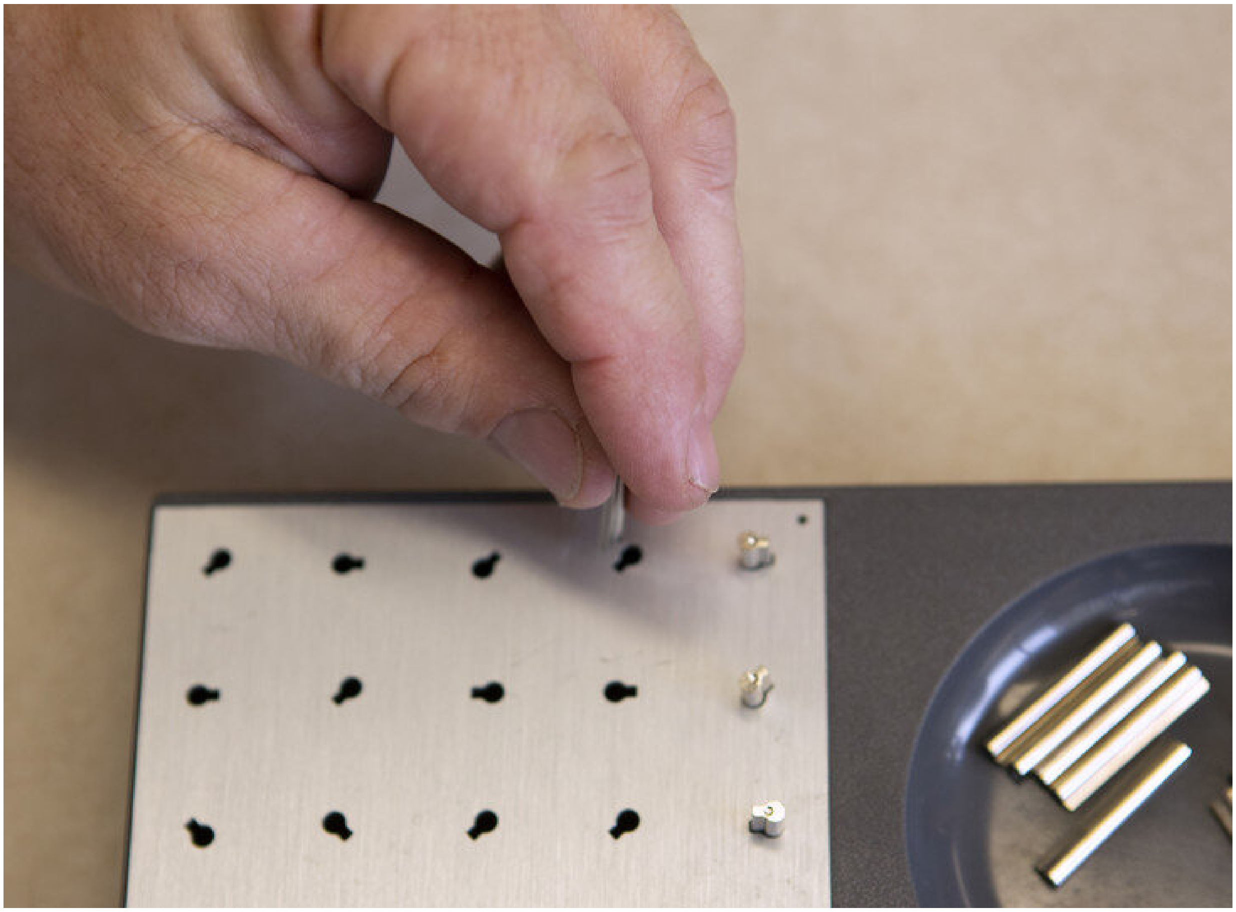
The resistance is strong

To Sainburg, the potential of applying this new knowledge to therapy situations was obvious: The "good" hand might benefit from therapy to try to recover what it lost due to the stroke.

That conclusion was not so obvious to others, however. The dogma that each hand was controlled exclusively by the opposite side of the brain was firmly entrenched, and the clumsiness of the "good" hand had always been chalked up to stress or fatigue or some other general reaction to the stroke. Sainburg's earlier work on handedness had been well received, but when he started presenting his work on the "other" hand of stroke patients, he got a very different response.

"It's the wrong hand, Bob!" he laughs, dropping into the broad English accent of the hapless Wallace of Wallace & Gromit, the stop-action show about a man and his dog. "I keep thinking of the line, 'It's the wrong trousers, Gromit!' For me it was 'It's the wrong hand, Bob!'"

He heard that refrain for years, at professional meetings, from colleagues, even from friends. The interactions often became heated. "I had to go to a lot more conferences, trying to get our story out there to clinical scientists so they would see that this is not crazy," says Sainburg. "We are absolutely not suggesting that therapists ignore the 'bad' hand, but that they include testing the motor abilities of the 'good' hand into their assessments, and include treatment of this hand if it is indicated."



Even more challenging is the task of putting small, flanged pegs into holes. Credit: Penn State Health

Treating the wrong hand

Finally, in 2015, Sainburg was awarded a grant by the American Heart Association to do a pilot study to test his ideas about doing therapy with the "good" hand of stroke patients. The grant did not come easy.

"We put in the proposal for just a little bit of money, enough to get patients in and test this," he recalls. "And they said, 'It's the wrong hand.' So we sent back a revision and said, 'We know it's the wrong hand, but here's why.' And they gave it to us."

In that study, 15 patients whose "good" hand showed substantial deficits in coordination were given training for that hand for an hour and a half, three times a week. They worked with the Kinereach, focusing on the specific skills the hand was having trouble with, and did standard exercises to improve skills like stacking cups, clipping a clothespin to a line, tracing shapes, and throwing and catching a ball. After only three weeks, the patients scored 20 percent higher on standard tests of hand function. Even better, they all reported improvements in their ability to do daily tasks—with the fringe benefit of becoming more active in general.

"One patient said, 'My wife doesn't have to come in the bathroom and help me in the morning,'" says Sainburg, "He's leaning down and putting his socks on with his good hand, he's getting up and getting his lunch, instead of sitting on the couch and letting his wife do it for him. Which, as you can imagine, is a massive, life-altering thing for her and him."

With those encouraging results, Sainburg, along with Carolee Winstein at the University of Southern California, won funding from the National Institutes of Health for more detailed and extensive studies. In the first experiment, which started in January, the patients will receive training of their "good" hand for five weeks, to see if they will improve in functional independence and activities of daily living more than control participants who receive traditional therapy focused on the "bad" hand. Patients will be tested before and shortly after the training period and again four months later, to see if progress they made during training is maintained. Sainburg and Winstein will also do scans of each patient's brain and spinal nerve tracts before and after the training, to look for changes that might be related to the therapy.

Boyer's "good" arm and hand—secured to a mouse-like cursor and sensors that track their movements—move in the space below the surface where the game appears. Credit: Penn State Health

The results from this study will help Sainburg design future experiments to refine the treatment protocols. He hopes to develop specific recommendations so that, in addition to therapy for the "bad" hand they do now, therapists will also test the "good" hand and do appropriate training of that hand where it's needed.

Acceptance

After so many years of being told he was working with the wrong hand, Sainburg is enjoying the sense that his hypothesis about motor control and handedness is being taken seriously. "It's not like it's accepted, but it's accepted enough that we can pursue it more," he says.

Sainburg is delighted, and more than a little surprised, to find himself back in OT mode after years in fundamental neuroscience. That wasn't his goal at the outset. He just wanted to know more about how the brain controls movement.

"I knew it was important to understand these mechanisms, but I didn't know that it was going to be directly applicable," he says. "And I certainly didn't think that we were going to do that application. It's pretty satisfying. It's pretty fun."

He's also come to a new understanding of the battle he went through to get to this point.

"When I was younger, I thought that resistance is a bad thing, that people just don't want to accept new ideas," he says. "And then I realized it's a good thing. It's a filtering system. I think if you didn't have that, you'd have people in science jumping down rabbit holes at too high a frequency. It's frustrating when people don't believe you, but at the same time, why should they believe you? You really have to show evidence, evidence, evidence, before people start to change their minds."

Provided by Pennsylvania State University