

Alternative understanding of brain leads to new treatments for stroke patients

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The idea of complimentary dominance — both hemispheres of the brain contribute to different aspects of movement in both halves of the body — was developed by Professor Robert Sainburg, pictured here, who studied the hypothesis it for decades. Credit: Dennis Maney / Penn State. [Creative Commons](#)

Since the early 20th century, researchers believed that movements on the right and left sides of the body were controlled by the opposite hemisphere of the brain and that handedness resulted from the dominant side doing a better job at controlling movements.

Nearly 30 years ago, though, a researcher at Penn State proposed the complementary dominance hypothesis—the idea that both hemispheres of the brain contribute to different aspects of movement on both sides of the body. Now, those decades of work—including independent research by other scientists—are informing [clinical trials](#) to test new interventions for people who have experienced strokes.

Robert Sainburg, Dorothy F. and J. Lloyd Huck Distinguished Chair in Kinesiology and Neurology at Penn State, and his team reviewed the existing research literature—from basic science experiments more than 20 years ago to recent intervention trials for [stroke patients](#).

Overall, the researchers said that complementary dominance has led to a better understanding of how the brain works and has guided the development of new treatments for people who have experienced strokes. They published their review in [the *Journal of Physiology*](#).

"Approximately 50% to 70% of people who experience a stroke survive, but many of those survivors have a long-term disability," Sainburg said. "That means there are hundreds of thousands of people each year in the United States alone who could benefit directly from this research and other studies that improve rehabilitation for stroke survivors."

Strokes occur when there is an interruption of blood flow to the brain, either due to a blockage or burst blood vessel. A stroke can damage parts of the brain that control movement and disrupt communication between the brain and muscles.

Much of the evidence to support left- or right-brain dominance, according to the researchers, comes from studying strokes. If someone has a large stroke in the movement center on one side of their brain, the other side of the body commonly displays significant control problems and can become weakened or paralyzed.

The same side of the body may exhibit weakness or other issues, but the assumption previously existed that the same side was unaffected.

This assumption meant that the standard course of physical rehabilitation for stroke patients has been to improve function on the side of the body most affected by the stroke, according to Sainburg.

Once that side became as capable as possible, people were taught to compensate for lost function with the less affected side of the body. Research by Sainburg and others, however, demonstrated that both sides of the body can be affected by a significant stroke.

"When I started this work in the 1990s, colleagues literally told me that I was throwing my career away pursuing this idea," Sainburg said.

"In their minds, it was settled science that each side of the body was controlled by the opposite brain hemisphere. Today, acceptance is rapidly emerging among neuroscientists and clinicians who work with stroke patients that both sides of the brain affect movement on both sides of the body. Currently, our research is exploring the full clinical implications of this knowledge."

Despite initial hesitancy from the field, over the past five years, Sainburg and his co-authors found that these ideas have started to become applied more broadly. Many laboratories have now published articles that described deficits in the ipsilesional—or so-called "good"—arm following a stroke. Some of these studies also examined

how to rehabilitate these deficits.

Now, the team is analyzing data from a large-scale clinical trial they conducted from 2018 to 2024, testing the effectiveness of therapies informed by their initial research for people who have experienced strokes in a single hemisphere of their brain. Preliminary results are promising, the researchers said.

Understanding the importance of each hemisphere

Around 20 years ago, before the complementary dominance hypothesis—initially referred to as the dynamic dominance hypothesis—was more widely understood and accepted, Sainburg and his collaborators employed techniques from neuroscience and biomechanics to investigate the relationship between the brain and body.

"The idea that there was a 'good' side and a 'bad' side in a healthy brain—rather than two sides doing different things—seemed absurd to me," Sainburg said.

"We know that in language production, the [left side of the brain](#) handles syntax and word choice, and the right side of the brain processes intonation for emotional expression. We believed something analogous must be happening in movement."

Sainburg and his colleagues examined whether a person's non-dominant arm and hand are better at some tasks or elements of tasks than the dominant arm.

Their research demonstrated that the dominant hemisphere of the brain—the [left hemisphere](#) in right-handed people—was better at smooth, accurate and efficient limb movements.

Their research also demonstrated that the non-dominant, right hemisphere of the brain was better at stabilizing the left arm in unpredictable situations, like if a person is pushed without warning.

Central to the hypothesis is the idea that both arms access both sides of the brain. Both sides use the same control systems, but each side relies more heavily on the specialization of the opposite side brain hemisphere—the one more closely connected to control of that limb.

Dozens of research teams around the world have independently assessed the neural basis of handedness, contributing to these findings and adding to the understanding of how both hemispheres of the brain affect both sides of the body, Sainburg said.

"This work provided strong evidence of lateralization—the understanding that each hemisphere can uniquely provide control over specific aspects of movement," said Nick Kitchen, postdoctoral researcher in kinesiology at Penn State and co-lead author of this publication. "This means that people who have strokes on one side of the brain can experience loss of that control on both sides of their bodies."

Sainburg and his collaborators then examined deficits in the less-impaired arm following a stroke. They found that people with strokes on one side of their brain had differing movement deficits in their less-impaired arm, depending on which hemisphere of the brain was affected.

When people who experienced strokes in their left hemisphere attempted to reach for objects with their left arm, the initial direction of their movement was less accurate than it would be in someone who had not experienced a stroke.

When people who experienced strokes in their right hemisphere

attempted to reach for an object with their right arm, they were less accurate at stopping their hand at the right location.

"This research and similar studies demonstrated the deficits that can emerge on the less-impaired side of the body following a stroke," Kitchen said.

"This mechanistic approach—from [basic science](#) through studies of real patients with brain lesions—is needed to fully understand these movement deficits and improve the rehabilitation of stroke survivors."

Supporting people who survived strokes

Once the researchers confirmed that a stroke in either hemisphere can impact both sides of the body, they began to develop potential rehabilitation practices for the less-impaired arm of stroke victims.

In a 2020 pilot study that served as a proof of concept for the larger scale clinical trial the researchers are currently concluding, Sainburg and his team asked people who had a stroke in the left hemisphere of their brain to play a virtual air hockey game with their left hand to rehabilitate the accuracy of their directional movement.

People who had a stroke in the right hemisphere of their brain played a maze-tracing game with their right hand to rehabilitate the accuracy of the destination of their hand.

After three weeks of training, people were 19% faster at completing the Jebsen–Taylor Hand Function Test, a common test to measure the dexterity of stroke survivors' hands. Results also showed that patients retained the gains six weeks later.

"Stroke is a huge public health burden," said Brooke Dexheimer, who

earned her doctorate in 2022 from Penn State and served as co-lead author on the review paper. She is now an assistant professor of occupational therapy at Virginia Commonwealth University.

"It's one of the leading causes of long-term disability, and many people never make a full recovery. Studies like these are the next step in improving how we tailor rehabilitation after stroke. The ultimate goal for many of us in this field is to help improve how we treat neurological injuries and get people back to doing the meaningful things they need and want to do in their daily life."

More information: Nick M. Kitchen et al, The complementary dominance hypothesis: a model for remediating the 'good' hand in stroke survivors, *The Journal of Physiology* (2024). [DOI: 10.1113/JP285561](https://doi.org/10.1113/JP285561)

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