The Plastic Brain

By SARAH SCOTT
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On a fine day in September 1995, Howard Rocket, a hard-driving 47-year-old entrepreneur, leaped for a pass in a friendly touch-football game in downtown Toronto. He slipped and fell on the back of his head, and a minute or so later, he woke up with a wicked headache that wouldn't go away. Then some weird dark spots floated into his field of vision. He ignored the danger signals until three weeks later, when he was home alone. Suddenly, Howard lost control of his arms and legs. A sharp pain pierced deep inside his head; darkness was closing in. He groped his way to the phone and, in a cool moment of calm before he collapsed, he slowly tapped 911.

Howard was lucky to make it through the night. His brain had been attacked by one of the deadliest forms of strokes, a basilar thrombosis, a clot that blocked the blood from flowing through the largest artery to the brain stem, at the base of the brain, where it connects to the spinal cord. It kills most people, but Howard was saved by doctors who injected a drug to break up the clot. In the days that followed, though, their prognosis was grim: Howard would never regain the use of his left arm or leg. His muscles were fine, but the parts of the brain that directed them were seriously damaged. In other words, he'd better get used to a wheelchair. "It was the best thing they could have told him in the hospital," Howard's daughter Dana recalls. "It gave my dad such fuel to prove them wrong."

And so he did. Determined to walk his daughter down the aisle on her wedding day, Howard applied every speck of his energy to rigorous physiotherapy. If you made your left foot move over and over again, he figured, eventually the brain would get the message and create a new pattern between those remaining brain cells that would tell the left foot what to do. After he learned to stand, he strapped his left foot onto the bike pedal and started pedaling. On the first day he lasted for 30 seconds, but he persisted. It was doing like sit-ups for the brain. Twelve years later, after thousands of hours in the gym, Howard danced on both feet. His doctors were amazed. "It was dramatic," said Dr. Robert Willinsky, the neuroradiologist who had saved Howard's life with the blood-clot buster. "He's a poster child for sure."
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It turned out that Howard's hunch was right: It is possible to retrain your brain to make up for the part that is out of order. A generation ago, that idea was dismissed as folly by most medical practitioners. They thought that the adult brain was like a machine: It couldn't change or grow, all it could do was break down. But over the past couple of decades, brain scans, such as Positron Emission Tomography (PET) scans which were introduced in the 1970s to show the brain in action, have helped scientists discover that the conventional thinking about the brain was wrong. If one part of the brain is injured, as Howard's was, another part of the brain can be trained to take over. It takes rigorous practice, sometimes over years. But brain scientists now know that thinking and activities can physically change the brain. They call it *neuroplasticity*, the brain's ability to change

itself, either by forming new connections between existing brain cells – or by sprouting new ones.

"We now know that when we have thoughts, we rewire the so-called hardware in our brains," says Toronto psychiatrist Norman Doidge. His book, The Brain that Changes Itself (2007), chronicles the mind-blowing discoveries of scientists who found that the brain could change as a result of thoughts and experiences: "They show that the brain changed its very structure with each different activity it performed, perfecting its circuits so it was better suited to the task at hand."

The idea that thoughts or activity can physically change the brain has profound implications, says Doidge. While researching the book, "I met a scientist who enabled people who had been blind since birth to begin to see, another who enabled the deaf to hear," he writes. "I met people whose learning disorders were cured and whose IQs were raised; I saw evidence that it is possible for 80-year-olds to sharpen their memories to function the way they did when they were 55. I saw people rewire their brains with their thoughts, to cure previously incurable obsessions and traumas." They did this by repeated mental exercise. Thinking, in other words, can change the way your brain functions.

Meditation is a prime example of repeated mental sit-ups. To see whether meditation alters the functioning of the brain, University of Wisconsin psychiatrist Richard Davidson fitted electrodes on the brains highly practiced Buddhist monks and novices. The results he reported in 2004 were remarkable. When monks meditated about "unconditional loving-kindness and compassion," they generated powerful gamma rays, the type involved in higher mental activities like perception and consciousness. Thinking, in other words, changed the way their brains function.

Meditation has a powerful effect on physical sensations like pain. Melissa Munroe, a former Canadian champion body builder, got the news at age 30 that the lump in her throat was Hodgkin's lymphoma, and it was so advanced that it had spawned tumors in her chest, near her heart and her lungs. Melissa will never forget what the doctors said: "We can't operate on you. You have cancer everywhere, from your head to your toes." They gave her three months to live. Melissa chose to fight and took such a heavy dose of chemotherapy that she collapsed in her downtown Toronto apartment. Her sister, woken by the yapping of her chihuahua, revived Melissa with CPR and artificial respiration. The pain from the tumors pressing onto her organs was excruciating, even for an athlete accustomed to pushing herself beyond knowable physical limits. So Melissa turned to a psychiatrist, Dr. Tatiana Melnyk, who taught her how to use her mind to ease the pain.

Pain is a physical sensation, Melnyk told her patient. But Melissa's emotional response to her pain was amplifying it. To remove the echo effect, Melnyk advised Melissa to focus on the actual feeling of pain instead of running away from it. What kind of pain was it? Where was it? Where was the border between pain and no pain? "Don't judge it; just sit with it," Dr. Melnyk advised Melissa. "Dr. Melnyk taught me to be really present in the moment," said Melissa. By meditating, thinking in this disciplined way, Melissa was able to control the way her brain dealt with the physical sensation of pain. She'd feel the pain,

but not be controlled by it. “I was almost able to objectify pain. It was something I was experiencing, but it was not me.” Melissa defied the odds: Five years later, she was cancer-free, and free of pain.

But how does it work? How is it possible that repeated thoughts or activities, like Howard’s relentless physiotherapy, can physically alter the brain? One way is to create new connections between existing brain cells. These neurons in the brain send and receive electro-chemical signals. We have plenty of them – an estimated 100 billion inside each of our brains. Thinking, it turns out, can alter these neurons so they’re better communicators.

Thinking might also alter the body’s DNA, which contains the instructions to make the proteins that a cell needs to function. Research, mostly done in the 1980s and 1990s, shows that “thinking, learning and acting can turn our genes on or off, thus shaping our brain anatomy and our behaviour,” Doidge writes. It is “surely one of the most extraordinary discoveries of the 20th century.” How this works, no one knows for sure, but Doidge thinks that “when you think thoughts repeatedly, you turn on genes to make proteins that change the structure of the neurons and increase the number of connections between brain cells.”

The brain can also produce new brain cells. In his lab at the University of Lethbridge, neuroscientist Bryan Kolb demonstrated that the brain can do this by giving rats a stroke that damaged their brains. He showed they could not only make new brain cells, but use them to help rebuild the physical and thinking functions that were damaged. Kolb and his group discovered another stunning feature: In the two weeks after injury, a rat’s newborn brain cells migrate to the injured site and sit there, waiting for orders. His tests on rats show something few would have believed a decade ago. If these newborn brain cells are properly stimulated, they can start functioning and help the brain regain its ability to do things, like direct the leg to lift. Kolb’s work underlines just how important rehab is for the injured brain. Now scientists are investigating whether the stimulation that rehab provides might actually increase the production of new brain cells to speed recovery.

One of the brain’s two nurseries is in the hippocampus, a key part of the memory functions. Scientists at the University of Toronto report that newborn cells start boosting memory after only one month. They found a way to chemically tag the newborn brain cells of healthy mice, and then they taught the mice to swim to a platform. After plenty of swimming practice, the mice remembered where the platform was. Then the scientists killed the mice and checked their brains. Sure enough, the newborn brain cells with the chemical ID tags had been recruited for the memory task. Research in Toronto and elsewhere also shows that the environment affects how many new brain cells are born, says Paul Frankland, the Toronto neuroscientist who led the research. Cocaine and stress, for instance, cuts the neuron birth rate; running and educational activities increase it.

Clearly, the brain can change far more than scientists once thought. In the scientific world, it’s called neuroplasticity. In Ian Bradley’s world, it’s called hope. Ian is a tall 20-year-old with a stubble of a beard. When he was in Grade 7, he still couldn’t read; his

spelling was at a Grade 4 level. “I thought I was a big dummy, that’s for sure,” he said. His mother Mary pushed him through elementary school by spending four hours every school night reading the textbooks to him and writing down his answers. “It was tough,” she said.

Then Ian’s father discovered Arrowsmith School. Its founder, Barbara Arrowsmith Young, was herself a gifted student with a profound learning disability that made it impossible for her to understand the meaning of what she was reading or what people were saying. She cured herself, through mental exercises such as reading a clock with hands not just for the hour and the minute, but for the second and even smaller units of time. Then she developed exercises to strengthen the parts of the brain that weren’t functioning properly in young people. Ian spent three years at the school, reading clocks on the computer, tracing letters and matching symbols. “It’s so tiring, it just kills you,” he said. But after three years, he could read at a Grade 8 level. He read his first book, The Hobbit. Now, finishing off Grade 12 at a high school in Etobicoke, he’s on the honour roll and aiming for a career as an engineer, or as a pilot. “Before life was so bleak,” he said. He didn’t have any confidence in himself. “Now the sky’s the limit, literally.”

The new discoveries about the brain give tremendous hope to young people with a learning disability, to the victims of stroke, who are dealing with the loss of part of their brain, and to the legions of people struggling with chronic pain. It is not, of course, a magic cure, but the medical profession is starting to realize that the brain can change itself, as Doidge put it, far more than anyone thought. “We are just scratching the surface of the breadth and the mechanisms through which the brain can change, and how areas of the brain can take on a new responsibility that you would not have imagined before,” said Dr. Andres Lozano, the neurosurgeon who helped to save Rocket’s life. When some cells in the brain cease to function, because of a stroke for example, other cells can take over. A good example is the blind person who reads Braille, said Lozano. Researchers have discovered that the information from a blind person’s fingers is processed through the visual cortex. “They’re seeing with their fingers,” says Lozano. Now doctors and researchers are seeking to understand and control the brain’s amazing ability to change. They’re testing drugs that may help the brain sprout new cells, and they’re now understanding why a go-getter dentist in Toronto was right after all. Repeated mental exercises, sit-ups for the brain, can change your mind and your body.