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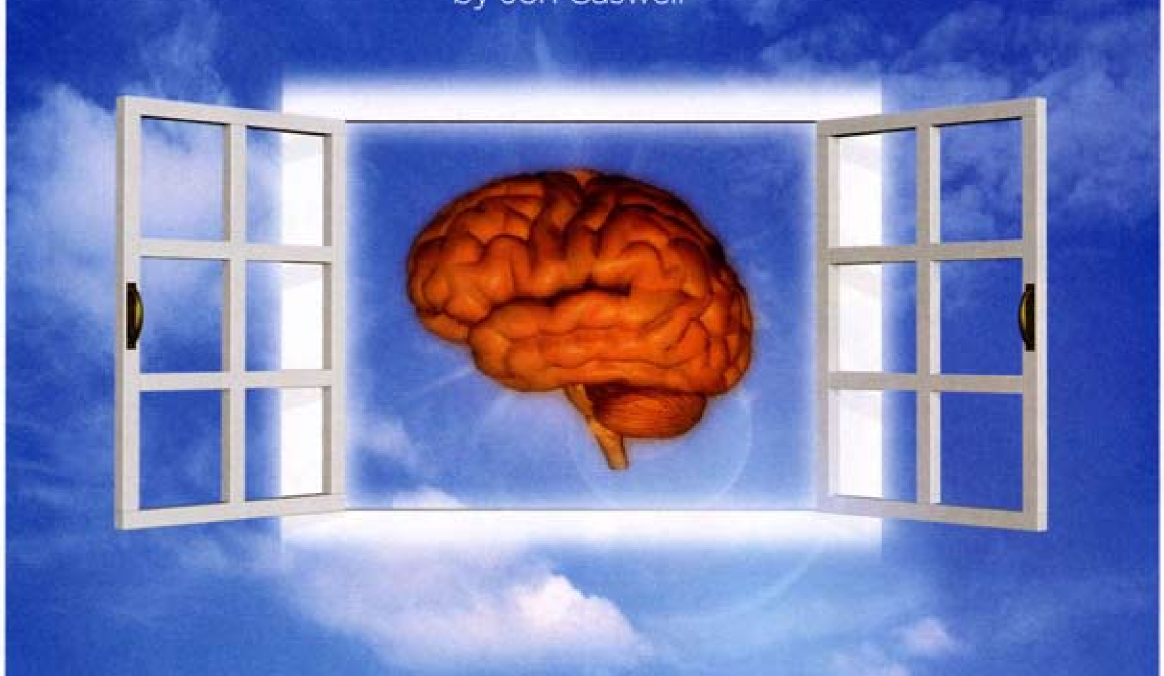
STROKECONNECTION®

New Developments in Rehab

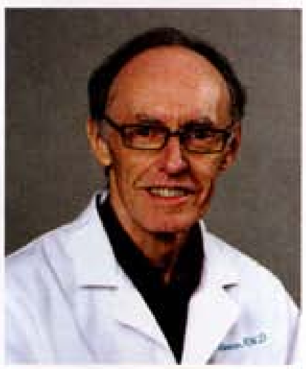
by Jon Caswell



Neuroplasticity is a big word for a revolutionary concept — the brain's ability to reorganize and rewire itself. For stroke survivors, neuroplasticity is the beginning of a whole new paradigm of recovery. Where once the six-month window of recovery was the gospel of rehab, in the future the prime directive will be stimulating neuroplasticity, according to a leading researcher in the field.

"Neuroplasticity, or brain plasticity, is the natural rewiring of brain cells in response to the environment and experience, including therapy," said Dr. James Stinear, director of the Neuralplasticity Laboratory at the Rehabilitation Institute of Chicago (RIC). "Examples are learning to play piano, or learning to walk again following stroke. Without neuroplasticity, recovery of movement would not be possible following stroke."

There are two types of brain plasticity. In ***physiological plasticity***, existing brain cells change how they communicate. In ***anatomical plasticity***, established nerve cells grow new fibers that transmit signals or completely new nerve cells develop. Nerve cells communicate by neurotransmitters, organic chemicals made by the body that pass across the microscopic gaps between cells (synapses). The connection between brain cells can be strengthened by increasing the amount of neurotransmitter passing between them. "This physiological plasticity can form very rapidly, but it may not persist," said Dr. Stinear, who is also research assistant professor in the Department of Physical Medicine and Rehabilitation at the Feinberg School of Medicine at Northwestern University in Chicago.



Dr. James Stinear

At the cellular level, millions of existing connections among cells communicate in a specific pattern. Some connections are strong and some are weak. "The connectivity pattern can change due to an experience or injury, making previously weak connections strong or strong ones weak," Dr. Stinear said. "That change in connectivity results in a different pattern of movement. That change is likely to persist, providing we keep practicing the new movement."

Old dogs can learn new tricks; so can injured brains. And practice appears to be the key to turning on the brain's plasticity, although the potential is there as long as we are alive. "Just as repetition is the key to a healthy person learning a new motor skill, repetition is also important for stroke survivors," Dr. Stinear said. "Repetitive movement can induce plasticity even when the movement is passive, as when a therapist moves a patient's arm. It appears the feedback from the moving limb to the brain promotes plasticity. If therapy produces a small recovery of a particular movement, the survivor should conduct 'mass practice' of that movement, building it into a useful movement sequence."

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Scientists are attempting to harness the brain's ability to rewire itself. Let's look at a few advances in rehab that take advantage of the brain's plasticity.

Therapeutic Thinking

Stroke survivors often complain about the cost of rehab, and insurance is increasingly denying claims for needed therapies. Dr. Stephen Page, associate professor in the Departments of Rehabilitation Sciences and Physical Medicine & Rehabilitation at the University of Cincinnati Academic Medical Center, has developed and tested a low-cost, low-tech way of enhancing neuroplasticity and stroke recovery. It's called "mental practice," and if you can think, you can do it.

"It's well-known that when you mentally practice a movement, you fire the same muscles as if you were actually doing that task," Dr. Page said. "We now know that the areas of the brain controlling that movement also fire as if you're performing the skill."

Mental practice involves mentally rehearsing a specific movement in sensory-rich detail. World-class athletes commonly use this kind of mental rehearsal to enhance their performance in competition. In Dr. Page's most recent experiment, two groups of survivors received 30 minutes of therapy twice a week for six weeks. Following the sessions, the control group got 30 minutes of guided relaxation, while the experimental group received 30 minutes of mental practice.

A taped voice led the subjects through five minutes of relaxation followed by suggestions for internal, cognitive images: Survivors mentally rehearsed the motor skill practiced during therapy that day. For example, when mentally practicing reaching for a cup, there was a sensory-rich description of the setting, say the kitchen or a restaurant. Then the survivor was taken through the visual image of reaching for the cup from a first-person perspective, as well as the associated sensations: the feeling of extending the elbow and fingers, the texture and weight of the cup. Each task was mentally practiced several times, lasting a total of 20-25 minutes. The final minutes of the tape allowed patients to refocus into the room.

Dr. Page observed dramatic differences between the two groups. Survivors receiving mental practice showed significant reductions in affected arm impairment as well as increases in daily arm function. "People who had only a little wrist movement at the beginning could grasp a spoon or a cup by the end," Dr. Page said. "At the International Stroke Conference we also showed that this type of mental practice also affects neuroplasticity. We obtained before-and-after neuroimages of participants' brains, and, after mental practice, the brains were really lit up. Usually these new activations occurred in new places where there was initially little to no brain activity."

Mental practice can also act as a bridge to modified constraint-induced movement therapy (mCIT), a reimbursable outpatient therapy developed by Page and his colleagues that requires some initial movement in the wrist and fingers. The combination of participating in mental practice, followed by mCIT, allows patients to make even greater gains than they would with mental practice alone.

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"Mental practice offers the potential to produce more opportunities for the brain to rewire and, thus, more physical changes to occur," Dr. Page said. "Moreover, survivors can try it on their own at home without special equipment. And some mental practice of a task has been shown to be better than no practice of any kind." Occupational therapists trained to break down tasks into small movements may be able to help work out the descriptions for a mental practice tape or CD that describes a movement from start to finish. For optimal results, however, Page suggested that patients and clinicians consider working with a psychologist trained in mental practice.

Remodeling the Brain

Constraint-induced movement therapy (CIMT) is arguably the most revolutionary advance in stroke recovery in a hundred years. Since 1993, when Dr. Edward Taub of the University of Alabama Birmingham proved that stroke survivors could improve arm and hand function by constraining their unaffected arm and performing "mass practice" of movement with their affected hand or arm, CIMT has become much more widely available. The great news for survivors is that it's effective with those who have had strokes years before, which disproves the six-month window of opportunity rule.

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Dr. Edward Taub and research assistant Lynne Gauthier

Now Dr. Taub and researcher Lynne Gauthier have used neuroimaging to show that there are structural changes to the brains of survivors using CIMT. "Prior research has demonstrated 'functional' changes to the brain from CIMT," said Gauthier, a graduate student in psychology, specializing in neuroimaging. "By functional, I mean increases in blood flow or cortical excitability, which can fluctuate on a moment-to-moment basis. Our study is the first to show changes in the structure of the brain as a result of rehab, and these changes occur on both sides of the brain." This may be evidence that the brain is reorganizing itself to meet the demands of the environment.

Two different treatments were administered to determine which aspects of CIMT promoted changes to the brain. Although both groups got the same amount of physical therapy in the laboratory (three hours a day for 10 days), one group was told to continue using their affected arm at home for everything. "We almost nagged that group," Gauthier said. "What we found was that the changes in grey matter we observed are proportional to the amount and quality of the survivor's arm use at home. In other words, those using their weaker arms to do activities of daily living at home not only showed better quality of movement, they also showed the biggest changes in the brain. People are essentially changing their brains by complying with their therapy."

The next step is to investigate how to increase those changes.

Think to Move

To profit from CIMT, survivors must have at least a small amount of residual movement in their affected arm. For survivors whose affected limbs are completely paralyzed — 30 to 40 percent of all survivors — there is virtually no treatment available.

Clinical neurologist Dr. Leonardo Cohen is chief of the Stroke NeuroRehabilitation Clinic at the National Institutes of Neurological Disorders and Stroke, National Institutes of Health (NIH). He and a team from the University of Tubingen in Germany wanted to see if there was a way to help survivors whose limbs are completely paralyzed.

Human brains work in a mirror-image fashion — the left hemisphere controls the right side of the body and vice versa. After subcortical stroke, the connection between the brain and hand, for instance, may be interrupted. "Our concept is that the brain activity is intact, despite the injury, and what is broken is the communication between the brain and hand," said Dr. Cohen, who is also chief of the Human Cortical Physiology Section of the NIH.

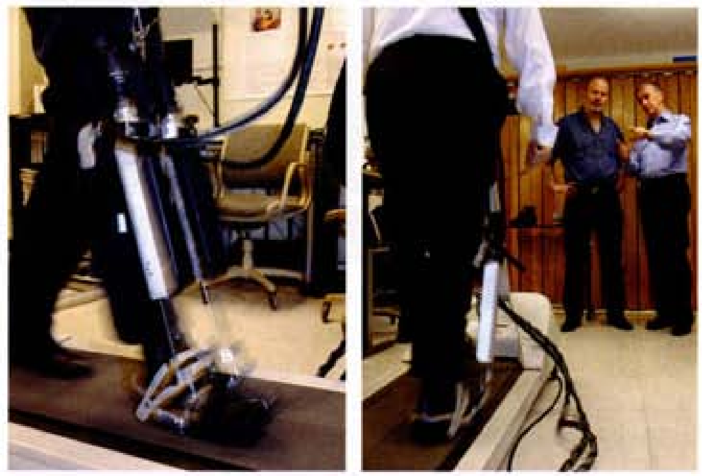
Dr. Leonardo Cohen

The idea behind their investigation was to utilize brain activity originated when survivors imagined moving a paralyzed hand to control a hand orthosis attached to the paralyzed hand. "We wanted to see if the brain activity that in a normal brain would lead to a hand movement could induce the movement of a hand orthosis. Could a brain/computer interface bypass the stroke lesion that resulted in the paralysis?"

Dr. Cohen and his team demonstrated that it is possible for survivors whose hands are paralyzed to control movements of the hand orthosis by imagining that their hands are moving. "This concept is extremely exciting, but the challenge is in working out the technical issues that will move it from the proof-of-principal level to accomplishing significant life activities. Some day, perhaps, survivors could think about a particular movement and wear a glove that performed the movement they imagined. That will require a substantial amount of technological development, but that's the goal."

Anklebot

"It appears that we are at the cusp of a revolution in rehabilitation medicine, and therapeutic robotics is at center stage," said Dr. Hermano Igo Krebs, a principal research scientist in Mechanical Engineering at MIT. Dr. Krebs and Dr. Neville Hogan, professor in Mechanical Engineering and Brain and Cognitive Sciences at MIT, are co-creators of MIT-Manus, one of the first therapy robots used for recovering arm movement. More recently they developed the Anklebot to help stroke survivors recover movement in the ankle, which is key to balance and normal gait.



Drs. Krebs and Hogan evaluate the Anklebot in action

The Anklebot is a computer-control system that takes advantage of the natural dynamics of the lower limbs. According to Dr. Hogan, previous approaches to robotic locomotor therapy have attempted to *impose* a pattern of lower limb motion. "Natural walking doesn't work like that," said Dr. Hogan. "It involves a complex and dynamic interaction between the lower limbs and the world, which may be suppressed by controlling leg motion. Our approach is highly interactive and attempts to augment, rather than suppress, the natural dynamics of the limbs."

The MIT team just completed a trial of the device at the Baltimore VA Medical Center. "The results were much better than we anticipated," said Dr. Krebs, who is also adjunct professor of Neurology at Weill Medical College of Cornell University and the University of Maryland School of Medicine. "We observed an improvement in unassisted walking speed between 21 to 67 percent." A 2007 survey on electromechanical gait trainers, which did not include the Anklebot, reported that robot-mediated therapy leads to positive results but not to greater walking speeds. "Maybe we were just lucky, but it appears that our vision was correct, that the ankle is the most important joint for gait and balance."

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If the shoe fits, it must be an Anklebot

Hogan and Krebs also measured the effect of Anklebot therapy on the stiffness of the ankle and found positive benefits. "Ankle stiffness is important for several reasons, not least of which is balance," Dr. Hogan said. "Abnormal ankle stiffness may increase the chance of falling.

"It's hard to resist hyperbole when talking about the Anklebot," continued Dr. Hogan. "At a minimum, it promises to bring the sort of reliable, sustained benefits to balance and walking that we have seen in the upper body with MIT-Manus: significant reduction of impairment, combined with a surprising reduction of pain, even for survivors many years post-stroke."

The Therapist Is Listening...in Cyberspace

As stroke families know, aphasia and treatment are like a lock and key — without the key of adequate speech therapy, language typically remains locked away. And yet insurance rarely pays for the prolonged, one-on-one therapy necessary to recover fluid communication.

"We are looking at ways in which we can provide more treatment at less cost," said Dr. Leora Cherney, who directs the Center for Aphasia Research at the Rehabilitation Institute of Chicago (RIC). "A lot of the treatments that we are investigating are computer based, because therapists are expensive. This is one way that people will be able to get therapy on an intensive basis at a reduced cost. Right now we are looking at treatment over the Internet so we can reach people who live too far away from a therapy center or have transportation barriers."

The speech therapy they are delivering is Oral Reading for Language in Aphasia (ORLA). Other studies have shown ORLA to be effective when provided by a speech-language pathologist. The treatment has been computerized and uses state-of-the-art virtual therapist technology. "This allows the person with aphasia to read aloud and ultimately speak sentences at the same time the words are produced by a life-like, animated computer character who serves as the 'virtual' therapist," Dr. Cherney said.

The Web-based ORLA program is downloaded to the survivor's home computer. When the person logs into the program, he or she is connected to a host computer at RIC, where a speech-language pathologist can monitor the session at the same time that it takes place. The therapist can interact with the survivor via a Web cam or by e-mail during the practice session, and provide feedback or modify the difficulty level of the tasks. Recordings from every practice session are stored, so the therapist can also retrieve information about the survivor's responses later. The program allows the therapist to simultaneously watch and interact with four people, all practicing with the "virtual" therapist in their homes in different locations.

"The ORLA program is easy to use and most people can practice their reading aloud independently with the 'virtual' therapist on the computer screen," said Dr. Cherney, who is also associate professor of Physical Medicine and Rehabilitation at Northwestern University's Feinberg School of Medicine. "So in reality, the speech therapist may only need to monitor each person for five to 10 minutes of the practice session." This means that the person with aphasia can practice as much as they need to, without being limited by the clock as in a regular therapy session, but the time spent with the speech therapist is minimized.

"We are presently conducting a clinical trial in which we are evaluating the effectiveness of the Web-based ORLA treatment," Dr. Cherney said. "If our results are positive, there will be important implications for reducing treatment costs while increasing access to speech therapy. We are very excited about the potential of this new delivery system."

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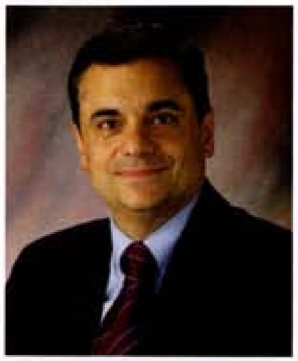
A patient working with a virtual therapist

Where Virtual Reality Meets the Reality of Stroke



Dr. Ross Zafonte

As any stroke family can attest, stroke is not virtual reality — the fear and deficits it spawns are about as real as it gets. But virtual reality may prove to be a means of recovery. At least that's what they are investigating at Spaulding Rehabilitation Hospital in Boston. "We are studying the use of visual feedback therapies to improve motor recovery in stroke survivors," said Dr. Ross Zafonte, vice president of Medical Affairs at Spaulding and chair of the Department of Physical Medicine at Harvard Medical School.

Spaulding is investigating the use of the Nintendo Wii (pronounced "wee") game console in a rehabilitation setting. Some in the media have dubbed this "Wii-hab." Through this console many different interactive videos can be accessed and put on a screen. For example, there is a program where the player spars with a virtual boxer; in another, the player beats virtual drums that are arranged in an arc around his body. Depending on the program, the survivor gets to practice different body movements, building up the number of repetitions that are the key to triggering new connections among brain cells.

Wii-hab provides several advantages over conventional therapy. First, it allows survivors to practice therapeutic movement independent of a therapist, which should increase repetitions while decreasing cost. The virtual environment is more visually stimulating than a rehab room, and that, too, may make a difference. And it's fun, which could enhance its acceptability with patients. "Perhaps the most exciting possibility is that ultimately patients can take it home and continue therapy there," Dr. Zafonte said.

A potential problem is that the games on the Wii don't represent truly functional activity, like shaving or getting dressed. "This is an important point of our investigation because in general our experience has been that non-functional activities don't translate into functional behavior."

Although survivors can go out and buy their own Wii console, Dr. Zafonte advised against it. "Right now, survivors are better off going to a therapeutic center that's working with this technology. It's not for everybody, and it's not yet an approved intervention.

"We are still in a study period on this technology, still refining who will benefit," Dr. Zafonte said. "It will take years to iron out the details, but I am very optimistic about it."

With Wii-hab, the survivor gets to practice different body movements and build up repetitions.

Therapist and survivor in a Wii-hab session

Defying Gravity

Sarah Housman

For stroke survivors with hemiparesis, the weakened limb is often too heavy to move against the force of gravity. For years, therapists have used the buoyancy of water or a friction-reduced environment to help survivors work their weakened limbs. At the RIC, occupational therapist Sarah Housman and other researchers have experimented with a non-robotic arm orthosis, called T-WREX, to improve functional arm movements.

"The T-WREX is 'passive,' meaning it does not contain any motors that would help a patient move," said Housman. "It makes the arm feel lightweight through the use of rubber bands instead of motors."

In Housman's experiment, two groups received 24 one-hour therapy sessions. One group used the T-WREX, the other received traditional therapy. Traditional therapy consisted of sliding the arm forward, backward and side to side on a tabletop surface. The table provided support for the arm, and a towel was placed under the arm to reduce friction during movement. Such exercises are commonly included in home exercise programs and group therapy sessions. Individuals in the T-WREX group practiced moving the arm in a large 3D workspace while it was supported in the gravity-eliminating orthosis. With T-WREX, the participant's

Housman helps a survivor with T-WREX therapy

arm movement was displayed on a computer screen, which allowed them to play computer simulations customized to the survivor's movement capability. Although a therapist set up both types of exercise, the participants completed the exercises with minimal help. Survivors in both groups had some movement in their shoulders and elbows, but not a lot, before participating.

After eight weeks of therapy, investigators evaluated the results. "Both groups showed significant improvements in arm movement and self-reported quality and amount of arm use during functional activities," Housman said. "When the patients were tested six months later, individuals in the T-WREX group had significantly larger improvements in arm movement. They also reported a greater preference for T-WREX training.

"This device allows survivors with very little movement ability to practice customized movement training without direct assistance from a therapist," Housman said. "Patients reported improved motivation to exercise with T-WREX compared to the traditional exercises because they were able to move their arms more easily and practice functional activities through the computerized simulations. We hope this improves compliance with treatment and the intensity of practice, which research studies have shown to be important contributions to motor recovery after stroke." SC