REPROGRAMMING

DAMAGED BRAINS

The computerized games are simple. The results for stroke survivors are anything but. A visit to a laboratory devoted to movement science turns up breakthrough science at its best.

Imagine that you survived a paralyzing stroke several years ago, which left you unable to move your right arm. Modern medicine and regular physical therapy for months afterward took you just so far. You still can't change that channel on your TV with the hand you used for 69 years before this disaster. And the paralyzed hand is of little help for other daily tasks like preparing dinner or bathing. But you've resigned yourself to this fate, forever. Then, a door opens at the UMDNJ-School of Health Related Professions' (SHRP) Laboratory for Movement Neuroscience and at New Jersey Institute of Technology's (NJIT) Laboratory for Movement Rehabilitation. You spend several weeks in a clinical trial for three hours at a time, five days a week, performing personalized hand and arm exercises while doing enjoyable virtual reality tasks in gaming simulations on a computer. One evening, absentmindedly, that useless hand reaches for the clicker at home and the TV comes to life. Your arm works. Voila! You surprise yourself. Now, you can hold the strawberries on the kitchen counter as you cut them up for a special dessert.

What actually happens to bring about this kind of remarkable recovery in patients who are past the traditional time frame for rehabilitation? "We're using robots interfaced with virtual reality simulations to help in the rehabilitation process," explains Alma Merians, PT, PhD, SHRP chair and professor in the Department of Rehabilitation and Movement Sciences. In the past, "the dogma for stroke survivors was that by six months after the event, they had reached a plateau where intervention was not going to change much behaviorally or neurologically. That's not necessarily thought to be the case anymore." In fact, a team of investigators at UMDNJ — including Merians, Eugene Tunik, PT, PhD, assistant professor, rehabilitation and movement science, and graduate students Hamid Bagce and Gerry Fluet, PT, DPT — along with colleagues at NJIT, Sergei Adamovich, PhD, associate professor, biomedical engineering, and graduate student Soha Saleh — are measuring robust 20-25% clinical improvements after training.

What's more, the clinical improvements are associated with changes in brain activity, a phenomenon called neural reorganization. Tunik explains, "When you perform any function, no matter what it may be, multiple areas of the brain are interacting, communicating with one another even across hemispheres. After a stroke, this functional connectivity (neural interaction) is not occurring normally. What we are seeing in the participants is that after train-

WORDS BY MARYANN BRINLEY / PHOTOGRAPH BY ANDREW HANENBERG

COPY TO COME
COPY TO COME ,

ing, clinical gains are paralleled by improved functional connectivity among multiple brain regions. This finding is dramatic and new because up until now, research on the benefits of training for stroke survivors showed only simple activation or de-activation of discrete brain areas, and research on the neural changes that occur from motor training in virtual reality is essentially non-existent."

Nearly 30 individuals with upper extremity impairment have so far participated in different aspects of these studies. These individuals' willingness to be involved in the study offered Merians an "aha" moment. At first, she had been trying hard to keep the volunteers on a tight schedule to save them time. Then, she realized, "They want to be here! They come early, hang around and stay late. Neuroscience literature about motor control and learning tell us that in order to make adaptive, functional changes in the brain, you need to do hundreds of repetitions of the task." The motivation and desire to engage in the virtual reality training offer a great way to deliver such needed practice to the patients. Keeping engaged was easy for the group in which the average age was between 60 and 70. They are in the trial not only because of the physical benefits to be gained, but also because the activities are fun. By playing songs on the keyboard of a virtual piano, hammering down imaginary pegs, catching birds on a screen and placing them in a virtual birdbath, or destroying objects in outer space while flying spaceships, they are re-wiring their brains. Subjects are really engaged in their activities during their time in the lab. "In today's healthcare environment, it is very challenging to provide the intensive mass practice required for neural reorganization," Merians says. These virtual reality paradigms offer a solution for this challenge.

ALMA MERIANS PHD, CHAIR, DEPARTMENT OF REHABILITATION AND MOVEMENT SCIENCES, UMDNJ-SCHOOL OF HEALTHRELATED PROFESSIONS

Subjects not only gladly took part in training, but also in neurophysiological measurements both before and after training. Functional magnetic resonance imaging (fMRI) and transcranial magnetic stimulation (TMS) are used to understand the effects that training in virtual reality has on neural reorganization in the brain. Tunik explains, "We are identifying specific forms of visual feedback in virtual reality that can be used to recruit the motor system in the brain. This means that a virtual reality training paradigm tailored to meet specific patient needs can be used as a vehicle for driving neural reorganization in the nervous system." For example, traditional physical therapy is limited in what it can do for a limb that is severely paralyzed because you can't easily perform exercises with it. Tunik continues, "Some of the forms of feedback in our virtual reality paradigms capitalize on what little motion remains, or use motion of the non-affected limb to accentuate, or make more salient, the feedback presented through virtual reality. Our data clearly show that doing so can significantly activate the sensorimotor system that is damaged in patients."

Virtual reality, according to Tunik, is a rich platform that can be manipulated to suit the patient's level and type of impairment. The game library currently consists of 13 simulations. "We certainly aren't the only lab focusing on this technology but we are perhaps only one of a few that has managed to integrate robotics with virtual reality into a single platform and to integrate that with fMRI and TMS experiments," Merians says. "We have engineers, neuroscientists and physical therapists involved," Tunik adds, "and we custom build most of our equipment. There are few labs nationally or internationally that cover all these bases."

"My aha moment was more of an aha year," Tunik admits. It is exciting to see the data begin to support the hypotheses to a degree he never actually anticipated. Originally, he had wondered, "Wouldn't it be innovative if we could use some visual illusions in virtual reality to get measurable changes in brain activity? Could we create sensory tricks to change a patient's brain in a therapeutic way?" Their results, seen in the neurophysiological data, soon showed that the answer to these questions was a resounding "yes." Bagce, too, could hardly believe the strength of the data when it all started to become clear. "Those were my aha moments," he adds. "I had thought, 'Can we really increase brain and motor cortex activity with these experiments?' So, the first time I ran off the results of just a few subjects and saw that every one of them was experiencing a sizable effect, I realized, 'this is really working.' A 10 percent beneficial effect would have been fine but we were getting 20 to 30 percent changes."

The game-playing is straight-forward. What happens in the brain is anything but. In the lab, a participant at a computer uses his or her good hand to play. Meanwhile, on the screen, a motionless, paralyzed hand can be made to look like it's doing the work of moving. "Every action is grounded in neuroscience with robot-controlled algorithms," Tunik explains. And the game experience can be tailored along the way to the abilities of the patients. Through the action in the game, "We know that we can increase blood flow to very specific areas that have not been working properly." This can be done even in instances when the affected, paralyzed, arm is actually at rest. The brain doesn't see that, however. It 'thinks' the motionless limb is moving and thus, "You activate the motor centers in the brain that would be controlling that bad hand or arm," Tunik says. "This is really a robust platform to make changes in the brain and behavior."

The ultimate goal of this remarkable research is to complete all of the studies with chronic cases so this type of therapy can be used with acute patients right after a stroke. "We're not there yet and are still figuring some things out but we know that the earlier you intervene after a stroke, the better you are," Merians says. Eventually, "We want to use this technology right there in the hospital, when patients have the most chance for recovery." ■

PHOTOGRAPH BY JOHN EMERSON

UMDNJ BRAINIAC: CHRIS MONAHAN

WORDS BY MARYANN BRINLEY

Chris Monahan is a man on the move — in his chosen field of nursing. Soon to graduate from SN's Accelerated Bachelor of Science in Nursing Program, he epitomizes a new wave of nurses with broader educational backgrounds, more diverse work histories and more opinions about their roles in healthcare. A graduate of Seton Hall University's honors program with a degree in finance and economics, he loves languages (German, Latin and his native English were among his favorite school subjects), spent years during high school and college working for an investment management firm, has a vivid interest in how economic policy affects politics, and went abroad to study business in London.

But when it came time to choose a profession, it was his deep attachment to his grandmother and the impact of her terminal illness and experiences with the healthcare system that inspired his decision. "I grew up in a two-family house with her," he says. "We were attached at the hip."

So, when she was diagnosed with ovarian cancer at age 66, not only was it a terrible shock for him, but also an eye-opener in many ways. "I knew that it was a bad cancer to deal with," he states. "Prior to this, she had had no medical conditions at all."

Monahan vividly remembers the nurses who came to give his grandmother home care. "They were positive, but honest. They kept things real," he says.

He noticed that the physicians, on the other hand, "were working from a model of fixing and conquering." But what truly disturbed him was a certain callousness that he noticed toward patients or what he calls "the physicians' nonchalance" about his grandmother and her illness. (She went into remission for six months, but died after just two years.)

Encouraged by his college professors to follow his interest in healthcare by applying to medical school, Monahan decided that nursing better matched his personal values—being good to others and giving back to your community. But perceiving himself as a leader, and someone who "likes to be responsible for my own decisions," he is intent on "breaking stereotypes of nurses being subservient to a physician."

He thinks that better utilizing nurses in expanded roles is the best way to reduce healthcare costs and that nurses will be pivotal in the changing healthcare environment. "We can save hospitals a lot of money," he says.

Monahan says the nursing program in Newark not only gave him the skills to practice his profession, but has prepared him in other ways by "exposing me to people from many different backgrounds and different viewpoints. I came into the program thinking I wouldn't make any serious friendships, but I made some really good friends."

As president of the Student Government Association, he has dedicated himself to creating a welcoming school environment, particularly reaching out to new students, and leading community fundraising. When he has some "down-time," keeping up with current events, travel and cooking (his best dish is eggplant parmigiana) are high on his list.

Who influenced him the most at SN? Instructor in the BSN Prelicensure Programs, Sharon Anderson, RN, APN, "embodies everything a teacher should be," he says. "She is so personally invested in the success of her students. When a teacher wants you to succeed, it brings out the best in you."

Monahan is thinking about his next big step — most likely it will be Navy nursing. "I would like to give back to my country." He sees it as both a "good opportunity" and a "coming of age experience." Oncology and critical care call to him.

What drives Monahan forward? His commitment to family and his deep rooted values. "My dad is a police officer. My mother is an administrative assistant. I come from a humble working background. I think sometimes when parents are affluent, they don't spend enough time with their children. They throw money at problems. I have incentive to work hard. It's big part of who I am." ■

PHOTOGRAPH BY ANDREW HANENBERG