WITHIN REACH

NEW THERAPIES FOR STROKE PATIENTS

STROKES are the leading cause of serious, long-term disability in the United States. Of some six million U.S. stroke survivors reported in recent statistics, only five percent will regain full use of affected arms and hands, which patients cite as a particularly disabling motor loss. And that's despite having had intensive conventional therapy.

But researchers are working to devise new and more effective therapies for helping people who have suffered brain damage caused by stokes to regain vital abilities. Among them are NJIT Associate Professor of Biomedical Engineering Sergei Adamovich, students from his department, and colleagues at the University of Medicine and Dentistry of New Jersey (UMDNJ). With the support of a \$1.3 million grant from the National Institutes of Health, Adamovich is developing better ways to rehabilitate individuals who have difficulty controlling their fingers, hands, elbows and shoulders. *continued* >

INDIVIDUALS WITH ARM AS WELL AS HAND IMPAIRMENT HAVE BEEN ASKED TO REACH OUT IN VIRTUAL ENVIRONMENTS TO BURST BUBBLES, TAKE CUPS FROM A SHELF AND PLACE THEM ON A TABLE, USE A HAMMER, AND GENTLY CAPTURE AND RELEASE BIRDS PERCHED AT DIFFERENT LEVELS ON TREES.

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Volunteers whose upper-body movements are still limited by the effects of strokes come to Adamovich's sixth-floor laboratory in Fenster Hall on the NJIT campus for two-week therapy sessions. They spend up to three hours a day, five days a week participating in therapy and research that combines virtual reality "video games" and the use of robotic devices designed to assist in the rehabilitation process.

Adamovich has been collaborating for over 10 years with two research scientists and physical therapists at UMDNJ – Alma Merians, PT, PhD, chair of the Rehabilitation and Movement Sciences Department, and Assistant Professor Eugene Tunik, PT, PhD. Their immediate objective is to help individuals who have had a stroke with an innovative approach to rehabilitation. They are also exploring how this promising therapeutic strategy may actually change neural connections in the brain as a patient's motor functions improve.

BUBBLES AND PIANOS

"Video game" is a convenient phrase to describe the virtual-reality (VR) environments that have been created to challenge volunteers with tasks they find difficult due to their strokes, Adamovich explains. For some of these activities, stereoscopic glasses enhance the three-dimensional VR experience with greater depth perception and immersion in the task presented.

In the course of the NJIT program, individuals with arm as well as hand impairment have been asked to reach out in virtual environments to burst bubbles, take cups from a shelf and place them on a table, use a hammer, and gently capture and release birds perched at different levels on trees. The goal is to improve the speed, smoothness and range of motion of shoulder and elbow movements. A virtual piano simulation helps patients improve their ability to move each finger individually. Sounding notes by touching the virtual keys provides realistic auditory and visual feedback while also tracking hand and arm movements.

"Stroke rehabilitation programs are most effective when they both engage and increasingly challenge the patient," Adamovich says. "An engaging virtual environment can aid in



this sense by systematically adapting the difficulty of a task to the ability of patients as they progress, and by motivating longer engagement in exercises than would likely be the case with conventional therapy."

HAPTIC HELP

In addition to sophisticated game-like activities in virtual environments, the NJIT program integrates the benefits of what are known as "haptic" devices. CyberGrasp gloves, fitted to the top of the hand, are used for hand and finger exercises such as the virtual piano. The Haptic Master system is used for activities involving the entire arm and shoulder. "These devices, essentially robotic exoskeletons, make it possible for patients to initiate and execute as much of a movement as they can and then provide varying degrees of assistance," Adamovich says. "This gives participants a satisfying, encouraging measure of success while incrementally forcing them to work at the highest level they are capable of given their impairment."

Results to date have been encouraging. For example, a group of 20 recent volunteers experienced motor-function improvement of 20 to 28 percent following participation in the NJIT program. They demonstrated improved independent finger flexion, finger speed, strength and range of motion as measured TMS, or transcranial magnetic stimulation (1), and functional MRI imaging (2) help to evaluate changes in the brain induced by robot-assisted therapy such as exercises with the Haptic Master (3). In the TMS experiment shown, Associate Professor Sergei Adamovich and UMDNJ Assistant Professor Eugene Tunik (standing, right) are working with volunteer Jony Scheynin to map the brain's response to tasks performed in virtual reality. Scheynin is a student in the joint NJIT/UMDNJ biomedical engineering PhD program. The photo was taken by NJIT BME alumnus Hamid Bagce '07, now an MD/PhD student at UMDNJ.

during training tasks, as well as in kinematic measures of reaching and grasping and clinical tests of upper extremity function.

According to Adamovich, age appears to make no difference when it comes to the potential for improvement. People have enrolled in the program as many as 15 years past their strokes and sometimes make better progress than individuals six months past the event.

THE NEURAL EVIDENCE

From one perspective, the most important outcome of the work being done in Adamovich's lab is the immediate, everyday benefits it can offer for participants who have suffered the trauma of a stroke. Equally significant, however, is the promise of fundamental insights into how haptic training in virtual environments

EALIZING THE FULL POTENTIAL OF OUR APPROACH TO THERAPY DEPENDS ON GAINING A THOROUGH UNDERSTANDING OF HOW SENSORY AND HAPTIC MANIPULATIONS IN VIRTUAL REALITY AFFECT NEURAL PROCESSES." – Seraei Adamovich, Associate Professor of Biomedical Engineering



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may induce positive changes in the brain by virtue of the brain's neuroplasticity – its capacity to establish new functional pathways after serious damage. This knowledge is basic to establishing the clinical significance of the research under way at NJIT.

A physicist and engineer, Adamovich has long been interested in how the brain controls motion, an interest that grew over the years as he became more focused on applied science. He emphasizes the importance of understanding the neural mechanism underlying the innovative rehabilitation strategy he is helping to develop. To this end, complementary studies of the brain's response to the virtual-reality and haptic therapy under investigation have been initiated.

Transcranial magnetic stimulation (TMS) and functional MRI are being used to map brain activity in real time as subjects perform tasks related to the therapy program, as well as to evaluate the reorganization in brain networks after therapy. Before coming to Assistant Professor Tunik's lab at UMDNJ for TMS evaluation, subjects undergo MRI scanning to generate an exact computer model of their brain. The model is used during the TMS session for precise positioning of the stimulation coil to ensure that the magnetic pulse enters the brain at a predetermined point of interest.

"Little is understood about susceptibility

Graduate student Qinyin Qiu working with a CyberGrasp Glove and the virtual piano therapy program

of brain function to visual, tactile and auditory manipulations within a virtual environment," Adamovich states. "It is critical to determine the basic neurological mechanisms of moving and interacting within virtual reality, and to consider how they may be exploited to activate neural networks associated with sensory

motor learning. Realizing the full potential of of our approach to therapy depends on gaining a thorough understanding of how sensory and haptic manipulations in virtual reality affect neural processes."

However, Adamovich adds that virtual rehabilitation for movement disorders has been developing more slowly than virtual technologies in other areas of health care. There are several reasons for this situation. Continued progress requires sophisticated integration of hardware and software, which is technically complex and expensive. The interdisciplinary nature of rehabilitation research also presents challenges. The design of interfaces to accommodate persons with impaired movement requires skills that span orthopedics, neuroscience, biomedical engineering, computer science and multiple rehabilitation disciplines.

Adamovich and his colleagues are working to address these issues. Ultimately, they hope, the therapeutic benefits of their research will be clearly validated and widely available to improve the lives of people who have endured debilitating strokes.

Author: Sheryl Weinstein is NJIT director of public relations.

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RESEARCH VOLUNTEERS STILL NEEDED: STROKE PATIENTS,

CHILDREN WITH CEREBRAL PALSY

CONTINUING RESEARCH

Research into stroke rehabilitation is continuing at NJIT, and more volunteers who have experienced strokes are needed for the program. Investigation of the benefits of virtual reality and haptic therapy is also being extended to children with cerebral palsy – the most common cause of physical disability in children. The therapeutic experience for cerebral palsy is being adapted for children in association with Children's Specialized Hospital in Mountainside, New Jersey.

Volunteers for the stroke program should be ambulatory and have transportation to the NJIT campus. The cerebral palsy program is seeking participants between the ages of 5 and 15.

Individuals interested in the stroke rehabilitation program and the parents or guardians of children who might participate in the cerebral palsy program should contact NJIT Associate Professor Sergei Adamovich at 973-596-3413 or sergei.adamovich@njit.edu.