

## **The Importance of Neurorehabilitation Research: Facilitating Recovery of Movement Following Neurologic Lesions and Developing Future Neurorehabilitation Researchers**

The drive to become a physical therapist and neurorehabilitation researcher are somewhat alike—you want to help people with a disability. However, neurorehabilitation researchers are specifically driven to improve the lives of people who have neurologic dysfunction. For many researchers, it is the knowledge that change can be induced in a damaged nervous system that lights the fire to do research. Moreover, neurorehabilitation researchers occasionally become fixated on the brain without fully incorporating the critical contributions of the spinal cord, peripheral nervous system, and the musculoskeletal systems in movement control and recovery of movement control after nervous system lesions. Rick Segal, PT, PhD, FAPTA, has dedicated his career of over 40 years to understand fundamental mechanisms underlying spinal cord plasticity, and the interaction and plasticity of the nervous system and musculoskeletal system. He has also dedicated over half of his career to facilitating the development of researchers through education and mentorship. Through ASNR, its annual conference, and committees, he has had a great platform for helping to develop future of neurorehabilitation researchers.



### **1. Can you tell us about your position and your research program?**

I became Emeritus Professor in the Department of Health Sciences and Research at the Medical University of South Carolina (MUSC) in August of 2023, but that did not end many of my activities at MUSC, including being the lead of the Medical Rehabilitation Research Resource (MR3) Network Coordinating Center and Co-Lead of the Didactic Interactions and Promoting Center Expertise Cores of the National Center of Neuromodulation for Rehabilitation (NC NM4R). NC NM4R was one of the six infrastructure centers of the MR3 Network. These activities ended April, 2025. I am also adjunct Professor in the Division of Physical Therapy at the University North Carolina (UNC) at Chapel Hill where I continue to mentor faculty. My laboratory research career centered on spinal cord neuroplasticity and the detailed organization and function of upper and lower limb muscles using anatomical, physiological, and imaging approaches. Although my laboratory research is over, I am still very active with two important mentorship programs: the Training in Grantsmanship and Rehabilitation Research (TIGRR) workshop and the Grant Writing and Mentorship in Education Research (GAMER) workshop. The latter involves my latest research interest in education research and its use for translation of research into practice.

## **2. What inspired you to get involved in neurorehabilitation research?**

As a graduate student at the University of Virginia, following three years as a practicing PT, I was fortunate to have experiences that thrust me into neurorehabilitation research, opening a new world for me and sparking hope for my patients with neurologic dysfunction. First, two of my instructors at the University of Virginia, Ossie Steward, PhD, (now at UC Irvine) and Ed Rubel, PhD, (retired from the University of Washington), introduced me to the concept of neuroplasticity. Both were major players in the plasticity world around 1980, and this was not discussed when I was in PT School. Also, while a graduate student, I had lunch with Geoffrey Raisman, MD, PhD, a professor from Oxford University who found the first evidence of central nervous system plasticity when examining fimbria-septal connectivity in 1969. This training at the University of Virginia and Raisman's findings stuck in the back of my head and "said" to me that my patients deserve better than usual care. As I felt this increased drive to make sure my work was more immediately relevant to humans, I began studies at Emory University related to neurorehabilitation with the mentorship and collaboration of Steve Wolf, PhD, a pioneer in neurorehabilitation. This work centered around neuroplasticity and also the importance of the interaction between the CNS and the neuromusculoskeletal system. Thus, my research program looked at: 1) Neuroplasticity and 2) The organization and plasticity of the neuromusculoskeletal system.

Through a collaboration with Steve Wolf, we were the first to show that the Jon Wolpaw operant conditioning of spinal reflexes protocol works in humans. Moreover, we later showed that the operant conditioning paradigm could successfully be carried out in people with partial cervical spinal cord injuries and spasticity, and that the effect persisted for up to four months without further training.

In collaboration with Steve Wolf and Art English, PhD (Emory University), our labs ran experiments to look at the detailed anatomical and physiological organization of the human neuromuscular system and its plasticity. In these studies, we showed that anatomical partitioning of motor units was functional in some of the tested muscles. I later used magnetic resonance imaging that was funded by a program project grant (see below) with Allen Song, PhD, (Duke University Brain Imaging and Analysis Center) and graduate student Sara Giordano, PhD, to look at the anatomical and functional organization of calf muscles and forearm muscles. Hopefully, someday these approaches and knowledge achieved may, for example, help determine precise locations for intramuscular electrodes for functional electrical stimulation (FES).

## **3. How has federal funding benefited or influenced your research/career?**

Federal funding ultimately makes the world go around. Federal funding helped advance my laboratory research and support my ability to facilitate opportunities for others. My first impactful funding award was from the Foundation for Physical Therapy, and then from American Paralysis Association (now Christopher Reeve), for operant conditioning of spinal reflexes in people with

spinal cord injury. The detailed operant conditioning studies of healthy individuals and some people with stroke was funded by an R01 awarded to Steve Wolf with me as Co-PI. After those grants, I have had significant federal funding including as a PI, Co-PI, or MPI continuously for over 30 years. The early funding allowed me and collaborators to do cutting-edge research on neuroplasticity and neuromusculoskeletal organization. This funding included a program project grant (PPG) with Art English as overall PI and me as a project PI and a translation core PI. This PPG was maintained for over 20 years. I also was fortunate to be a mentor for the NIH-funded Enhancing Rehabilitation Research in the South (ERRIS) grant writing workshop for 10 years. As ERRIS funding was concluding, I was asked to coordinate the writing and be PI of the follow-up to ERRIS, which was the TIGRR grant writing workshops. I was PI for 6 workshops and contact MPI alongside Edelle Field-Fote, PT, PhD, for 5 workshops, and I continue to serve on the Executive Committee. ERRIS and TIGRR have had an enormous impact on neurorehabilitation research with many of the mentees making significant impacts on our field. These programs and accomplishments of the people who have participated in them are great examples of how federal funding makes a huge difference.

Overlapping with me being PI and MPI of TIGRR was another outstanding use of federal funding for developing careers and research skill sets. This was the Interdisciplinary Rehabilitation Engineering Research Career Development K12 (IREK12) program with Jules Dewald, PhD, as PI. I served on the Executive Committee and was a recruiter for this program that developed the careers of engineers to be better rehabilitation researchers. This program was funded for 10 years and helped create a network of engineering rehabilitation scientists across the country, many of whom did work in neurorehabilitation.

Last but not least, during the past 10 years, I had leadership roles within NIH-funded infrastructure center grants, NC NM4R (Steve Kautz, PhD, overall PI) and the MR3 Network Coordinating Center. These grants were very impactful for neurorehabilitation research by funding pilot grants, supporting the mentorship of developing researchers, and putting on training symposia, etc. For example, pilot and mentorship funding from NC NM4R has yielded approximately 40 million dollars of funding for pilot awardees and mentees of the Center. The MR3 network contributed to the advancement of neurorehabilitation across the lifespan and across the translational pipeline, from cellular studies to health services research. As lead of the MR3 Network Coordinating Center, I am very proud of our accomplishments.

#### **4. What do people in your studies say about what it's like to be involved in your research?**

I think the greatest impact has been the federal grant awards and career promotions of mentees or trainees who participated in the programs I ran or helped to run. Some of these impacts (successes) arose many years after the initial interaction. When you get a message from a junior faculty member that they just got notice of awards for two R01's within a two-week period from two different programs, you have to think you did something right. Moreover, it feels better than receiving funding for your own work. I have received numerous similar messages over the

past 20 years. In addition to the successes of mentees/trainees in grant writing, the influence on overall career development of faculty has been incredibly rewarding. One mentee wrote me a note, after receiving a professional award, to tell me that our interactions changed her life. Yikes!!!

**5. What are some of the outcomes or impacts of your federally funded research that you are most proud of?**

As stated earlier, I am proud of all of the trainees and mentees from the mentorship programs I ran or helped run. With regard to laboratory and clinical research, I am particularly proud that we moved the operant conditioning work into humans and that Aiko Thompson, PhD, from MUSC has exponentially built on that to have great impact with patients. She has been amazing.

My career has seen me go from more of a lab-based researcher to relishing the opportunity to facilitate the development of research faculty careers and to also begin to focus on translation of findings using education research. It has been really meaningful to help start training a whole generation of new education researchers with the Grant Writing and Mentorship in Education Research (GAMER) workshop.

For me personally, as I have said already—mentorship and facilitation of career growth of others will be my happiest memories of my career. To me, this is our highest calling as faculty.