The Importance of Neurorehabilitation Research: Promoting Recovery of Goal-Directed Movement

From navigating through our environments to interacting with objects and other people, goal-directed movements are central to our everyday lives. However, for people who have had a stroke or other injury to the central nervous system, even routine actions may become a major challenge. While pharmacological treatments are important, behavioral interventions during rehabilitation are critical for restoring and optimizing function after neurological damage. Carolee Winstein, PT, PhD, FAPTA, FAHA, FASNR, has dedicated her career to conducting interdisciplinary research to better understand control, rehabilitation, and recovery of goal-directed movement. Dr. Winstein is a long-time ASNR Member, ASNR past President, and a current Member of our Education Committee. She has made valuable advances in the field of neurorehabilitation by developing and improving behavioral interventions that are grounded in the neuroscience of motor learning and the science of behavior change. In our interview, Dr. Winstein discussed her career and her contributions to the field of neurorehabilitation.

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

I retired from my professorship at the end of June of 2023. At the time, I was Professor of Biokinesiology and Physical Therapy with a joint appointment in the Department of Neurology in the Keck School of Medicine at the University of Southern California (USC). I had also been an active member in the interdisciplinary Neuroscience Graduate Program at USC for 25 years. Since the early 1990's, my research program has focused on the development of non-pharmacologic rehabilitation interventions, motivated and informed by brain and behavioral science, to enhance or even accelerate recovery in persons who have damage to the CNS. My research interests and contributions have spanned three main areas: 1) neuroimaging studies to improve our understanding of the underlying neural substrates and mechanisms involved in recovery, as well as to identify potential neuroimaging biomarkers that may predict recovery; 2) clinical trials of behavioral interventions and studies investigating behaviors such as limb choice and limb non-use after stroke; and 3) rehabilitation engineering research to develop and evaluate novel rehabilitation technologies and tools. I remain involved in neurorehabilitation research today with long-time colleagues and former students. My passion for the field includes mentoring junior faculty, writing perspectives, giving talks and webinars, and attending professional meetings.

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

My inspiration came from asking the 'why' question when I was a practicing clinician (physical therapist) at Rancho Los Amigos Rehabilitation Center. I wanted to understand why my patients showed such variable responses to my evidence-based interventions. However, this was in the 70's and early 80's when there was very little evidence supporting neurorehabilitation. The revolution in neuroscience pertaining to experience-dependent plasticity and recovery from neurological insults was on the horizon in rehabilitation science, and it foreshadowed a paradigm shift in our understanding of the mechanism of action for neurorehabilitation.

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

Hugely! I began with a small grant from the Foundation for Physical Therapy ($1.5 million over 3 years) in 2001 to establish a clinical research network which we called PTClinResNet that hosted four rehabilitation clinical trials (one phase II trial and three phase I trials). My department chair, James Gordon, EdD, PT, FAPTA, asked if I would lead this project. I was Associate Professor at the time and eleven years into my academic career. It turned out to be a tremendous career growth opportunity that had a major impact on my career trajectory. I learned the various aspects of clinical trial research and became a clinical trialist in neurorehabilitation. At the time, there were very few clinical trials in rehabilitation. While I had a small NIH grant, an R03, before PTClinResNet begen, after the network was established, I began competing more regularly for NIH funding. I had incredible collaborators, and we were successful with funding some of the earliest rigorous clinical trials in neurorehabilitation, including EXCITE (Extremity Constraint Induced Movement Therapy Evaluation), ICARE (Interdisciplinary Comprehensive Arm Rehabilitation Evaluation), and DOSE (Dose Optimization for Stroke Evaluation). I learned a tremendous amount from this experience and from collaborating with colleagues on some of the early trials of devices for neurorehabilitation, including the failed EVEREST trial that evaluated use of epidural electrical stimulation for improving upper limb motor function in stroke rehabilitation.

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

One of the benefits of doing research with human participants is that when you give them an opportunity to provide you with their perspective, you can learn so much. These insights inform your research approach and can lead to important breakthroughs. During the ICARE trial, we used an intervention called the Accelerated Skill Acquisition Program (ASAP). This intervention was designed at the interface of impairment mitigation, skill acquisition, and motivational enhancements. We engaged our participants in the problem-solving aspects of their own recovery. We were working with a gentleman, and he shared what he thought about always practicing tasks he found to be a bit challenging. He replied that, "If you don't practice things that are challenging, you never make mistakes. It's mistakes that you learn from. If you don't

make mistakes, you can't learn". These remarks were particularly interesting coming from a gentleman who, when he enrolled in our study several months earlier, had been very disgruntled and almost antagonistic about whether rehabilitation would help him.

This aspect of my research career (the patient perspective) has recently informed a deliberate switch to incorporating more qualitative research methods in my research collaborations, consulting, and writing. I encourage all neurorehabilitation scientists to think more about how you can learn from the patients and participants you work with and integrate their feedback to enhance your research and make it more relevant, translatable, and impactful in the real world.

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

I am of course proud of the results of our federally funded research for contributing to the science of neurorehabilitation, including motor learning, but I am most proud of my students and post-docs who benefited from the environment we created for them to learn many of the research skills which inform their academic careers. Federal funding plays a critical role in supporting trainees, giving them professional development opportunities, and allowing them to gain experience in conducting and disseminating research at a time when we really need engaged scientists.

Through innovative, interdisciplinary research and her commitment to supporting the next generation of neurorehabilitation researchers, Dr. Winstein has made lasting impacts on the field. The interventions and tools that she has developed are already being implemented to improve clinical practice and enhance recovery of function for individuals with stroke and other neurological conditions.