<u>Career Pathways: Claudio Ferre, PhD</u>

Following your curiosity may not produce a logical, linear career path, but this strategy has been a key part of my journey to finding a fulfilling career in neurorehabilitation. Looking at my credentials, it's easy to piece together a convincing narrative about how one step naturally led to the next. I received my Bachelor of Science degree in Psychology from DePaul University, followed by a PhD in Kinesiology from Columbia University. I completed a postdoctoral fellowship at the Burke Neurological Institute, Weill Cornell Medicine. Now I'm currently an Assistant Professor at Boston University in the Sargent College of Health and Rehabilitation Sciences and faculty at the Neurophotonics Center. I am also the director of the Development, Experience, and Motor Recovery lab, and my work is funded by a NINDS K01 and a NICHD R03 award. Like many other researchers, on paper, my career may read like a list of the usual steps in the recipe for a successful academic scientist, but like any good story, the details, the twists, and the turns are what make it interesting.

I vividly remember the genuine excitement and curiosity I felt as a child the first time my newborn sister clasped her tiny hand around my outstretched finger. *How does she know how to grab it!? No one taught her that!* My family often playfully teased me for being excessively curious and for asking questions without obvious answers. I didn't know it at the time, but internally, I was forming an appreciation for — and a sense of wonder about — the development of motor control in infants. The memory serves as an interesting reminder of the types of subtle, and often underappreciated, experiences that shape our interests and professional trajectories as researchers.

My work lies at the intersection of neuroscience, rehabilitation, and developmental science. The focus of my research program is to examine how sensorimotor experiences shape brain development in typically developing children, and children who are at-risk for or diagnosed with cerebral palsy. Our goal is to characterize mechanisms underlying motor development and impairment, with the hopes of using this information to develop novel therapies to improve motor function in children who experience perinatal brain injury. My lab's research is highly interdisciplinary. This is not the result of some teleological linear professional trajectory, but rather reflects the broad training experiences I obtained while pursuing research questions I was passionate about.

It wasn't even until my third year of college when I realized that scientific research was a professional career. I was a biopsychology undergraduate major who aspired to be a clinical psychologist. In my junior year, I enrolled in an Animal Behavior course and was instantly captivated by the work of ethologists and their natural history approach to systematic descriptions of an animal's behavior in its natural setting. My budding interest in ethology led me to begin working as an undergraduate researcher in the lab of Dr. George Michel on a project characterizing parental behavior in prairie voles. I spent hours slouched in an uncomfortable chair, staring at grainy videotaped recordings, and scoring parental behaviors in this astonishingly unique biparental rodent. My stint in rodent studies ended that year, but from that experience, I learned the importance of detailed and rich descriptions of behavior as a tool for studying development.

In addition to rodent studies of parental care, my undergraduate mentor had a separate line of work examining the development of hand-use skills in typically developing infants. Here, I had my first formal exposure to the study of motor development. The goal of this was work was to longitudinally track the development of hand-use preferences (i.e. handedness) in infants during the first year and a half of life. Infant handedness is a readily observable motor behavior in infants, and it thus lends itself well as a model of lateralization in the nervous system. I became so fascinated with the patterns and speed with which infants develop fluency with their hands, that I decided after graduation to move with my advisor to his new faculty position at the University of North Carolina at Greensboro and enroll in their doctoral program. I had graduated to a more comfortable chair and digital recordings (instead of video tapes), but the process remained very similar: meticulous observation and scoring of behavior to characterize developmental trajectories.

Together with my advisor, we embarked on a series of studies characterizing in detail how infant manual skills such as reaching, grasping, and bimanual manipulation emerge during the first two years of life in typically developing infants. During my early training, I gained a deeper appreciation of the power of rich behavioral descriptions for understanding the natural history of behavioral phenomena, such as infant manual skills. Although I was completely engrossed with the study of infant handedness, I became curious about motor skills in the context of early brain injury. After deep reflection and an inescapable feeling that something was missing from my training, I decided to transfer programs in order to obtain experience working with a clinical pediatric population.

In pursuit of clinical knowledge, I landed in the laboratory of Dr. Andrew (Andy) Gordon at Columbia University. As one of the first researchers to adapt constraint-induced therapy for children with hemiplegic cerebral palsy, I was drawn to the immediate clinical impact of Dr. Gordon's work. Despite my initial enthusiasm for learning about rehabilitation studies, I remember a sense of hesitation and feeling like an outsider in a field dominated by physical and occupational therapists. To my delight, I soon learned that my mentor Dr. Gordon himself had arrived at clinical research from a background in experimental studies of basic motor control. Pursuing threads that started with paradigms examining how typically developing children and children with hemiplegic cerebral palsy coordinate fingertip forces when grasping an object, Dr. Gordon observed that with sufficient practice, children with hemiplegic cerebral palsy were able to improve their ability to plan and scale forces appropriately when picking an object up off the table. The logic that intensive practice underlies changes in motor control in children with cerebral palsy became the driving force of the intervention work that I performed in Dr. Gordon's lab. Together with the team, we published a series of papers demonstrating how, with sufficient practice, children with hemiplegic cerebral palsy can improve dexterity, and bimanual skills. These improvements occur across different intervention settings and translate to functional changes that increase independence.

As I was finishing my graduate training, I received an unexpected email invitation to participate as volunteer in a pilot study that involved transcranial magnetic stimulation (TMS). My knowledge of the technique was limited, but I was nonetheless thrilled to receive the email given that it was from someone I viewed as one my science heroes: Dr. Kathleen Friel. Dr. Friel had recently completed a sequence of highly impactful studies using a feline model of cerebral palsy. These studies demonstrated how neuroplasticity could theoretically be harnessed for rehabilitation. At the time, Dr. Friel was making a bold transition from basic animal studies to working with human participants. Her new line of research aimed to use knowledge of activity-dependent plasticity and neurophysiology to examine the relationships between motor impairments and some of the disruptions and reorganization of motor pathways in children with unilateral brain injury. During my doctoral training, I had the privilege of receiving informal mentoring and learning from Dr. Friel. I was thrilled when the opportunity arose to do a postdoctoral fellowship in her lab. Importantly, the work I conducted with Dr. Friel filled an important gap in my training. I gained hands-on experience with neuroimaging and neurophysiology techniques — tools that provide us with an opportunity to characterize the relation between adaptive brain changes and improvements in motor function following intensive therapy.

In 2019, I moved to Boston University to start my own lab: the Development, Experience, and Motor Recovery Lab. Unable to come up with a clever or punny acronym, I prioritized meaning over marketability. I felt the themes in the lab name really captured the broad, interdisciplinary training that informs my research. My lab is comprised of two lines of work. In one series of studies, we are using a combination of optical imaging (functional near-infrared spectroscopy, fNIRS) and wearable sensors to longitudinally track the emergence of spontaneous movements during the first half year of life. Seemingly non-goal-directed or unintentional, spontaneous movements provide a rich source of sensory feedback that afford the infant with opportunities to learn from their own self-generated sensorimotor experiences. Using fNIRS, we hope to detail the impact these movements have for development of brain areas responsible for motor control in typically developing infants and infants at risk for cerebral palsy. In the second line of work, and building on the studies I began in Dr. Friel's lab, we are using a multimodal approach (diffusion tensor imaging (DTI), TMS, and fNIRS) to characterize how patterns of reorganization in response to early brain injury relate to motor impairments in school-age children with cerebral palsy. Our goal is to use this information to develop targeted interventions.

My career path has led to interdisciplinary training and a strong focus on using mechanistic information about the neurophysiology of early brain injury response and repair to guide clinical intervention. This path is the result of robust, supportive mentorship. I am so fortunate to have had the hands-on training and guidance I received from my formal mentors. They provided technical training, but more importantly, the types of supportive environments that allowed me to thrive as a researcher. New ideas were always welcomed, and independent thought was encouraged. I have also benefited from informal mentorship from researchers that I have come into contact with during my training. For example, countless times I have reached out to individuals like Dr. Jason Carmel, who has generously provided candid, yet encouraging, feedback on my grant applications.

When I reflect on my training and career path, I see now why I am drawn to be a member of an organization like ASNR. So many of the themes that emerge from my training are also values the society cares deeply about. Aside from the intellectually invigorating Annual Meeting which showcases cutting-edge neurorehabilitation research, there is a deep commitment to rigorous interdisciplinary science, diversity of thought, and mentorship of the next generation of rehabilitation scientists. As a member, I have directly benefitted from the commitment to these values. During my doctoral training, I was a recipient of an ASNR Diversity travel award which provided the opportunity to attend the Meeting and present my work. I vividly remember the highlight of that conference being a morning breakfast roundtable where, as trainees, we had the opportunity to have casual professional conversations with a lineup of rehabilitation science rockstars. My experiences that morning and the way the discussion leaders were genuinely interested in our work left a lasting impression on me.

My inquiries about the development of motor skills in infants have become more focused since my childhood. However, I am grateful to still be filled with the same fascination and wonder when observing how infants use their hands to explore the world. I am currently on parental leave as my second daughter is turning 4 months old. Two nights ago, I woke to the repetitive sound of her hand scraping the mesh netting of the sides of her bassinet. My first thought was, *I can't believe it's only 4:30 am, and she is already awake.* Yet, even in the grogginess of my disrupted sleep, my immediate next thoughts were curiosity about why she enjoyed the novelty of that sound; marvel at how those tiny hands actively sought out experiences with different textures, in the process developing somatosensory maps that will guide further development of what will one day become manual skills for exploring objects. These are all questions for another day, hopefully after a little more sleep.