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Sensorimotor Systems: Translating the Science into Best Practices to Optimize Recovery in Neurorehabilitation

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Our understanding of sensorimotor systems has grown significantly since the time of Decartes (1596-1650). The current challenge for clinician scientists like myself, whose work is at the intersection of motor control and neurorehabilitation, is the quest to translate that understanding into best practices to optimize recovery. Nearly 30 years ago, the seminal work of Nudo and colleagues revealed that an inherent capability of the adult brain, experience-dependent plasticity, was not only the foundational mechanism by which humans learn new skills throughout life, but it also appeared to provide a mechanism (i.e., cortical plasticity) for recovering functional movements after the paralyzing effects of stroke. The core principles of experience-dependent neuroplasticity including use it or lose it, use it and improve it, specificity, repetition, intensity, time and salience, found their way into my research program and programs of many of my colleagues. The field has evolved significantly over the last few decades, with a better understanding of brain-behavior relationships and beginnings of big data (e.g., ENIGMA stroke recovery) in sensorimotor systems, but now we face new challenges and opportunities. We now recognize the complexity of the brain-behavior system and the considerable variability in brain lesions, recovery trajectories, and responsiveness to treatment. Growth in the number of non-pharmacologic randomized clinical trials in neurorehabilitation signals some level of maturity, however the number of neutral multi-site trials points to a problem in staging with early phase mechanistic trials often neglected across motor intervention trials. We and others have recognized that a key ingredient of any intervention that requires a behavior change (i.e., use your paretic limb) is the motivation to participate in the practice that it will take to recover (i.e., coached and self-practice). Therefore, understanding what drives that participation is important in order to personalize sensorimotor training. We are entering a new age of Precision Rehabilitation that itself offers many challenges and opportunities. For this talk I have identified three interrelated grand challenges for this new age of precision rehabilitation and the associated rehabilitation goal. First, is the apparent disconnect between one's capability and actual performance (i.e., what you can do vs what you actually choose to do). The rehab goal is to increase performance to the level of capability/capacity. Second, is the need for higher-resolution data that reveals the time-varying (within and between days) processes that impact decision-making (e.g., to choose the paretic arm for action). The rehab goal is to better understand those fluctuations in order to tailor the intervention and feedback more precisely for that participant's profile. Third, we know that the dose of therapy matters, but understanding the specific parameters of dose (i.e., timing, total dose, duration, intensity) of sensorimotor training and how those parameters can be personalized to optimize outcomes is the challenge. The rehab goal is to maximize efficacy and efficiency of task practice. With these three exemplars, we offer some beginning solutions that may speed up the discovery process in this exciting time for sensorimotor systems research in neurorehabilitation.