

## Use of Targeted Neuromodulation Tools for Enhancing Upper Limb Motor Function Recovery and Rehabilitation

Course ID 108

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In this course, we will use a multimedia approach to introduce the concept and potential therapeutic utility of neuromodulation methods that aim to induce targeted plasticity in key pathways for upper limb (UL) motor function recovery after cervical SCI. In individuals with chronic cervical SCI, the excitability of cerebral cortex – spinal cord (corticospinal) pathway is diminished while proper regulation of spinal reflex excitability is often lost, resulting in impaired voluntary UL motor control. Yet, because CNS plasticity remains after SCI, it should be possible to target-induce beneficial plasticity to corticospinal or spinal pathways to benefit UL rehabilitation. Regaining arm/hand function is one of the top priorities of individuals with tetraplegia, and often most challenging. Mass practice and conventional therapy can help to improve functions to some extent, but without targeting relevant corticospinal or spinal plasticity, the CNS pathways that are critically important for UL motor function could remain impaired and hinder further recovery. Thus, methods to target plasticity to reduce the recovery-hindering problem may be able to enhance UL rehabilitation beyond what conventional therapy alone has achieved. In this course, we will introduce and discuss targeted plasticity-inducing neuromodulation methods such as paired associative stimulation (PAS) and operant conditioning which use stimulus-triggered muscle responses (e.g., spinal reflexes and motor evoked potentials). Reflexes and Motor Evoked Potentials (MEP) reflect the CNS state and the excitability of the pathways through which those responses are generated. PAS involves pairing of peripheral nerve stimulation and transcranial magnetic stimulation of the cerebral cortex with specific intervals to induce plasticity. PAS targeting spinal cord level has shown to increase corticospinal excitability and improve motor functions after SCI. Through muscle evoked potential operant conditioning (EPOC) training, a person learns and practices to change a behavior of a targeted neural pathway, and over time, this leads to improving impaired neural behaviors and motor functions. Through reflex operant conditioning, the brain's descending influence on the targeted reflex pathway changes, which in turn produces persistent changes in the reflex pathway and its activity, leading to wider beneficial plasticity in other spinal and supraspinal pathways and improving motor function. MEP up-conditioning targets plasticity to the corticospinal pathway and increases its excitability for the targeted muscle. By improving the SCI-weakened corticospinal drive, MEP conditioning enables more effective movement execution and induction of wider beneficial plasticity. For successful clinical translation and implementation of PAS and EPOC, or any other targeted plasticity methods, clearly describing the intervention technology to clinicians/practitioners is as essential as demonstrating effectiveness. Thus, the final section of this course will discuss possible strategies for effective clinical translation of targeted neuroplasticity interventions. We will consider critical steps informed by clinical trials, towards implementing and incorporating these new interventions into clinical practice.

**Learning Objective 1** To discuss the therapeutic potential and utility of neuromodulation approaches that aim to induce targeted neuroplasticity for improving upper limb (UL) function recovery after spinal cord injury (SCI).

**Learning Objective 2** To learn the principles of paired associative stimulation and muscle evoked potential operant conditioning that induce targeted neuroplasticity for enhancing neurorehabilitation in people with incomplete cervical SCI.

**Learning Objective 3** To discuss possible strategies for effective clinical translation of targeted neuroplasticity interventions; consideration of critical steps towards implementing and incorporating them into rehabilitation practice.