Module 9 – Neuroplasticity

Introduction to Neuroplasticity

Neurons communicate with each other in a highly complicated network that controls our movements, feelings and many functions in our body. Our neural network gets laid out before birth and fined tuned during early childhood where neurons find and connect to their appropriate targets. Much of our neuronal network afterwards remains relatively stable. Stabilizing our neural network is achieved by the formation and production of elements that prevent further growth such as the Perineuronal Net, or myelin around axons.

However, adaptations in the connectivity of the nervous system are essential to be able to respond to changes in the environment or our body, for example., when we learn a new task or are injured. The process of the brain and spinal cord being able to change its connectivity to adapt its functional abilities, is termed neuroplasticity.

After a SCI, plasticity occurs within the brain and spinal cord to help adapt to new challenges and make better use of circuitry that may remain intact. The beneficial effects of rehabilitative training leverage plasticity to help improve our functional capabilities after an SCI.

However, plasticity is also involved in the development of many secondary complications such as neuropathic pain, spasticity, depression and autonomic dysreflexia.

This can be termed "maladaptive plasticity" as it refers to plasticity in the nervous system that can lead to a disruption of the function, consequently heightening pain processing and sensitivity.

Ongoing research seeks to understand how plasticity occurring both within the brain and spinal cord affects functional abilities after SCI and how plasticity could be leveraged to promote function while avoiding unwanted side effects.

Plasticity can occur through various mechanisms. This ranges from changes in the structure of neurons, to changes in connections (called synapses), and even cellular changes (e.g., cellular excitability).

Understanding all of the mechanisms involved with plasticity are complex and involves adaptations to both neurons and glia throughout the entire neuroaxis. In this module we will focus on 2 mechanisms of plasticity that are both relevant to SCI: structural and synaptic plasticity.

Structural plasticity refers to changes occurring in a neuron that changes the amount of connections to and from that neuron. This can include sprouting of neurons to make more or alternate physical connections with other cells or to provide more space for other neurons to connect to.

Synaptic plasticity refers to changes occurring within a neuron altering how effectively neurons communicate with one another at the location where two neurons make connections.

Both forms of plasticity can affect how neuronal circuits function and both can be leveraged to improve functions that were lost to SCI. However, both forms of plasticity have also been implicated in the development of neuropathic pain, spasticity, and autonomic dysreflexia that arise after SCI.

We will provide an overview how research seeks to facilitate plasticity to improve function.

Finally, we will overview challenges with treatment approaches aimed at inducing plasticity and highlight the need for specific plasticity to safely improve function after SCI.