Neurorehabilitation using neuroprosthetic and robotic systems: steering the chaos of plasticity after severe spinal cord injury

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A severe lesion of the spinal cord induces complete and permanent paralysis below the level of the injury. Despite this lack of functional recovery, marked plastic changes take place in spared systems. Indeed, we will provide evidences that a substantial anatomical and functional remodeling of spinal circuitries spontaneously occurs after severe spinal cord damage. These complex and multifaceted changes in the structure and properties of spinal motor systems lead to a progressive degradation of functional capacities in the chronic stages of the injury. Could this plasticity be exploited to improve function? To address this hypothesis, we evaluated the capacity of neurorehabilitation enabled by electrical and pharmacological stimulations and robotic systems to appropriately remodel lumbosacral circuitries and spared intraspinal systems around the lesion site. We will show that use-dependent plasticity allows paralyzed rats to voluntarily control the pharmaco-electrically activated spinal circuitry and to regain the impressive capacity to initiate locomotion, walk freely overground, cross obstacles, climb stairs, and swim. These results highlight the delicate balance between bad and good plasticity after severe spinal cord damage.

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