Brain-Machine Interface (BMI) in paralysis

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ABSTRACT

Introduction: Brain-machine interfaces (BMIs) use brain activity to control external devices, facilitating paralyzed patients to interact with the environment. In this review, we focus on the current advances of non-invasive BMIs for communication in patients with amyotrophic lateral sclerosis (ALS) and for restoration of motor impairment after severe stroke.

BMI for ALS patients: BMI represents a promising strategy to establish communication with paralyzed ALS patients as it does not need muscle engagement for its use. Distinct techniques have been explored to assess brain neurophysiology to control BMI for patients' communication, especially electroencephalography (EEG) and more recently near-infrared spectroscopy (NIRS). Previous studies demonstrated successful communication with ALS patients using EEG-BMI when patients still showed residual eye control, but patients with complete paralysis were unable to communicate with this system. We recently introduced functional NIRS (fNIRS)-BMI for communication in ALS patients in the complete locked-in syndrome (i.e., when ALS patients are unable to engage any muscle), opening new doors for communication in ALS patients after complete paralysis.

BMI for stroke motor recovery: In addition to assisted communication, BMI is also being extensively studied for motor recovery after stroke. BMI for stroke motor recovery includes intensive BMI training linking brain activity related to patient's intention to move the paretic limb with the contingent sensory feedback of the paretic limb movement guided by assistive devices. BMI studies in this area are mainly focused on EEG- or magnetoencephalography (MEG)-BMI systems due to their high temporal resolution, which facilitates online contingency between intention to move and sensory feedback of the intended movement. EEG-BMI training was recently demonstrated in a controlled study to significantly improve motor performance in stroke patients with severe paresis. Neural basis for BMI-induced restoration of motor function and perspectives for future BMI research for stroke motor recovery are discussed.