Brain-computer interface robotic training and non-invasive brain stimulation for stroke rehabilitation: possibility or virtual reality?

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It is estimated that approximately 9 million people worldwide suffer from stroke every year and that almost 30% of stroke survivors suffering from irreversible motor impairments. Disability from stroke places a huge financial cost on the healthcare system and also incur great burden on the patient from the loss of work and increased medical cost. In most cases, the process of rehabilitation from stroke is often long and there is no guarantee of complete motor recovery. Furthermore, the multi-disciplinary nature of stroke rehabilitation makes such treatments time-consuming and costly to sustain.

In recent years, the use of brain-computer interface (BCI) robotic training is seen as a potential adjuvant therapy in stroke rehabilitation. The concept of BCI is to utilise neurophysiological signals during real-time motor-imagery (MI) and transform these signals into computer commands. These commands, in turn, drive a robotic manipulandum with the patient's affected limb secured to it. MI-related changes in brain activity can be recorded in several ways, including electroencephalograhy (EEG), electrocorticography, magnetoencephalography, functional magnetic resonance imaging, positron emission tomography, and functional near-infrared spectroscopy. MI is a process by which an individual produces a mental picture of an intended motor task in the absence of physical motor output, and this process elicits corticomotor activation patterns similar to actual task performance. MI also has the ability to effect neuroplastic changes following a period of training in healthy subjects and in stroke patients, which is likely to facilitate functional improvements during stroke rehabilitation. As such, it is hypothesised that the combination of both techniques (MI and BCI) may be used as a potential therapy in stroke rehabilitation. The reason for combining both paradigms can be seen as a two-tiered approach towards stroke rehabilitation, *i.e.* 1) activating central motoneuronal networks through the process of MI thereby enhancing neuroplasticity and, 2) providing sensorimotor feedback from the affect limb using passive manipulation with the aid of an end-effector manipulandum.

Although several MI detection methods have been trialled, EEG-based BCI is seen to have the greatest potential in a clinical rehabilitation setting due to its low-cost, portability and non-invasive setup. Our findings suggest that MI-BCI robotic training may be efficacious in stroke rehabilitation by facilitating brain plasticity. Furthermore, we found that that non-invasive brain stimulation prior to MI-BCI may improve patient's ability to produce enhanced neurophysiological activity that would allow for greater EEG detection.