Use of Neuromodulatory Approaches in Stroke Rehabilitation

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Cardiovascular diseases such as stoke are one of the leading causes of dead and disability in the world, and that number is like to increase in the coming decades.[1] Besides the conventional physiotherapy[2] there is still no effective treatment for several motor function disabilities. The patients remain with motor disabilities for the rest of their life. The developments of more effective treatments for these patients are one of the most critical goals for science today.[3]

The development of neuromodulatory interventions to induce neural plasticity is advancing at a rapid pace. The concept of neuromodulation is based on evidence that the Central Nervous System (CNS) can exhibit neuroplasticity that is enduring beyond the stimulus.[4] There are some different non-invasive neuromodulatory paradigms already described in the literature, including, Transcranial Magnetic Stimulation (TMS), repetitive TMS (rTMS), and transcranial Direct Current Stimulation (tDCS).[5] Paired Associative Stimulation (PAS) paradigms have been described that utilize an exogenous stimulation of the cortex repetitively paired with an exogenous peripheral nerve stimulus [6]. Peripheral electrical stimulation that provides an afferent input to somatosensory cortical projections, combined with a firing of cortical neurons has been utilized in PAS protocols to induce LTP by colliding a sensory input and motor output.[6,7,8,9] In these PAS protocols, cortical stimulation is most often induced using TMS as a non-invasive exogenous method of exciting the motor cortex. Peripheral electrical stimulation over a peripheral nerve which receives afferent information from the muscle of interest is used as the peripheral sensory input. Around 100-200 pairings of peripheral and cortical stimuli are delivered in most PAS paradigms and result in increased cortical excitability that outlasts the length of the stimulus to the extent that cortical excitability remained increased for at least 30 minutes following the intervention.[6,10] The timing of each stimulus in the pairing is important, if the peripheral afferent volley arrives at the cortex around the same time that the TMS is delivered then excitability in the cortex is increased. Conversely, if the afferent volley arrives around 10ms before the cortical stimulus, there is a decrease in cortical excitability.[6,10,11] There is some indication that the precision of timing may not be as stringent in the lower limb as it is in the upper limb, with a wider inter-stimulus interval difference for interventions that increased lower limb related cortical excitability being wider that the equivalent for the upper limb.[12]

Another emerging approach for stroke rehabilitation is Brain-Computer interface (BCI). Since the first brain-computer interface was described in the 1970s by Jacques Vidal, several studies have shown that there is a vast variety of use of how a BCI system can be used. The first published work, showing that using a Brain-Computer interface (BCI) system could modify the organization of the brain was done on monkeys in 1996 by Iriki et al.[13] and hence has the possibility improve motor function in humans as well. A BCI is a system that interprets brain signals generated by the person, allowing

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commands from the brain to be sent to an external device.

The combination of new rehabilitation paradigms, such as paired associative stimuli (PAS), which exploit cortical plasticity, with BCI's represents a novel application of this technology in people with neurological diseases. One possible way of doing that is that the BCI identifies the movement related cortical potential (MRCP) in the participants own electroencephalography (EEG) and uses this to trigger a PAS protocol that converges a peripheral afferent stimulus with the person's efferent output. The Movement-Related Cortical Potential Paired Associative Stimulation (MRCP PAS) intervention is a novel neuromodulatory paradigm that uses an endogenous cortical signal to provide the efferent output paired with an exogenous peripheral nerve stimulus and shows promise as a neuromodulatory intervention. The use of the MRCP as an endogenous signal within the MRCP PAS protocol has been studied in different conditions in healthy people and those with stroke. This MRCP BCI intervention has the potential to contribute to improved outcomes for people with stroke and to provide a cost-effective, sustainable intervention that can be implemented in rehabilitation facilities, hospital and private clinics.

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