

Motor Cortex Stimulation and Robotic Rehabilitation Training

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- Funding Agencies: NIH (through National Capital Area Rehabilitation Research Network R24), MERCE pilot project

Description:

Transcranial magnetic stimulation (TMS) is a method that can stimulate the primary motor cortex, and thus can be used to both probe and influence motor function. The latter represents a potential adjunctive method in rehabilitation. For instance, TMS could be combined with robotic rehabilitation to enhance the contribution of motor cortex to a goal-directed movement. Prior to using TMS in such a manner, however, its effects on movement within the robotic devices needs to be investigated, so that stimulation protocols can be designed to enhance, rather than interfere with, goal movements. There is therefore a need to conduct studies that evaluate movement maps and mechanisms of motor learning using TMS under conditions of impedance controlled arm movements.

Objectives:

The broad objective of this study is to use a non-invasive measure of brain physiology to obtain pilot data regarding cortical motor system mechanisms of motor control and learning in the upper extremity. Our objectives are to evaluate: (1) TMS-evoked muscle activation and movement maps in the upper extremity, (2) the effect of repetitive arm movements in a force field on TMS-evoked muscle activation, (3) the effect of TMS before and/or during arm movements on movement and motor learning while reaching in a force field, and (4) the effect of timing of stimulation on associative plasticity in the motor system.

Research Plan & Methodology:

The goal of this pilot study is to obtain representative TMS maps of movement and force production. In usual TMS mapping protocols, surface EMG monitors a single muscle and the coil is moved around the scalp, stimulating the cortex below while the size of the response (the “MEP”) is measured in that muscle. In this protocol, MEPs will be recorded, in multiple muscles, but the purpose of this study is mainly to map the TMS-evoked movement of the hand in the horizontal plane (Figure 1).

Transcranial Magnetic Stimulation causes Consistent Arm Movements

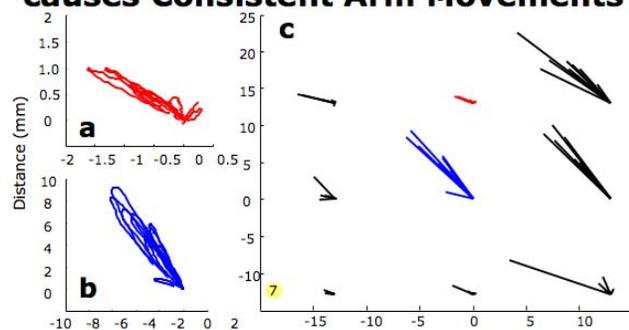


Figure 1: Movement trajectories in the X,Y plane. Both small (a, <1mm) and large (b, >1 mm) movements were elicited. (c) A grid of 9 maps (3x3 centered on hotspot) was created for each subject. Each map consisted of 10 movement vectors elicited by TMS over the same cortical location, and were arranged by stimulation location.

These movements will be recorded at rest, but also during cued movements performed against resistance, freely, or with assistance. After the best location for evoking a planar movement at rest is identified, the subjects will practice moving in the opposite direction, and the effect on MEP size and direction of evoked movement determined.

Milestones:

November 2007 – first set of pilot studies demonstrated feasibility of approach for objectives 1-3.
December 2007 – Dr. Jones-Lush replaced Dr. Judkins, began data analysis, received K-12 funding.

Future Grant and Publication Plans:

Plan R01 submission in response to PA-08-099 (Mechanisms of Functional Recovery after Stroke)
Submitted two abstracts to Society for Neuroscience with two papers in preparation.

Clinical Relevance:

Impedance control robot training therapy is a novel approach to rehabilitation of stroke survivors with chronic hemiparesis. Its purpose is to support the patient's active but insufficient movement with forces that assist the performance of purposeful motor sequences. This approach may optimally access the recovery capabilities of the motor system to re-establish voluntary movement ability. However, the degree of motor recovery that can be accomplished with this, or any other method, is often unsatisfactory, particularly in individuals with severe motor impairments. It is this problem of incomplete motor recovery in stroke that is addressed in the proposed research. But applications will not be limited to stroke, because other brain disorders, such as multiple sclerosis and traumatic brain injury, share similar mechanisms for motor impairment, and likely, for recovery.