ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA
DIPARTIMENTO DI PSICOLOGIA
"RENZO CANESTRARI"

Project Title: Tracking neural plasticity and cortico-cortical interactions underlying perception and action in people with multiple sclerosis and neurodegenerative diseases, and healthy controls.

Duration of the grant: 12 months, renewable

Abstract: This research project explores neural dynamics and the plasticity of cortico-cortical networks in healthy individuals and patients with multiple sclerosis and other neurodegenerative diseases. The study will use image-guided transcranial magnetic stimulation (TMS), electromyography (EMG), and electroencephalography (EEG), as the primary neurophysiological techniques to investigate premotor-motor networks underlying action control and temporo-occipital networks underlying visual perception in people with neurodegenerative diseases and healthy controls.

Objectives:

- To investigate cortico-cortical connectivity of premotor-motor network underlying action control and temporo-occipital networks underlying visual perception in healthy individuals using TMS-EMG and TMS-EEG co-registration.
- To examine the differences in cortico-cortical connectivity of motor and visual networks between healthy individuals and people with MS and other neurodegenerative diseases using TMS-EMG and TMS-EEG co-registration.
- To evaluate the neuroplasticity of premotor-motor and temporo-occipital networks and behavioral performance in response to cortico-cortical paired associative stimulation (ccPAS) intervention in healthy individuals.
- To examine the differences in neuroplasticity of premotor-motor and temporo-occipital networks and behavioral performance between healthy individuals and patients with multiple sclerosis and other neurodegenerative diseases following ccPAS intervention.

Methodology:

Participant recruitment: healthy individuals without neurological disorders and patients diagnosed with MS or other neurodegenerative diseases (e.g., Alzheimer's Disease, Parkinson's disease) will be recruited for the study.

TMS-EMG co-registration: cortical excitability and cortico-cortical connectivity will be assessed by applying single-pulse TMS over the primary motor cortex and recording motor evoked potentials (MEPs) via Electromyography (EMG; TMS-EMG co-registration). MEPs will be also induced using the dual coil TMS over premotor and motor areas to assess cortico-cortical interactions and connectivity strength.
TMS-EEG co-registration: cortical responses and network dynamics triggered by TMS-induced neural stimulation will be traced with EEG recording following application of TMS pulses over premotor, motor, temporal and occipital areas, in order to investigate the immediate and direct effects of TMS on brain activity and connectivity.
ccPAS: neural plasticity will be examined through a ccPAS intervention, involving TMS pairing of premotor-motor and temporo-occipital areas.
Behavioral assessment: clinical assessments, such as disease severity and cognitive performance, will be conducted to evaluate the impact of neurodegenerative diseases on cortico-cortical interactions and plasticity. Moreover, performance on visual and motor tasks will be conducted in patients and healthy controls, to investigate the effect of ccPAS on behavior and the relations with neurophysiological markers of cortico-cortical connectivity.
Data Analysis: statistical analysis will be performed to compare behavioral, TMS-EMG and TMS-EEG measures, neurophysiological parameters, and clinical assessments between groups, utilizing appropriate statistical tests and models.
Expected Outcomes: The study aims to provide insights into the cortico-cortical interactions and plasticity of premotor-motor and temporo-occipital areas in both healthy individuals and patients with MS and other neurodegenerative diseases. Findings would contribute to establishing neurophysiological markers of altered cortico-cortical connectivity and plasticity in neurodegenerative diseases, potentially contributing to our understanding of the underlying neural mechanisms. The research outcomes may have implications for the development of targeted interventions, such as non-invasive brain stimulation techniques, for the modulation of cortico-cortical interactions and neuroplasticity in patients with neurodegenerative diseases.

Keywords:
Transcranial magnetic stimulation (TMS), electromyography (EMG), electroencephalography (EEG), dual-coil TMS, cortico-cortical paired associative stimulation (ccPAS), TMS-EMG coregistration, TMS-EEG coregistration, brain connectivity, neural plasticity, premotor-motor areas, temporo-occipital areas, action, perception, multiple sclerosis, neurodegenerative diseases.

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Training plan and activities of the research fellow:

Training activities: readings, discussions with the supervisor, direct involvement in lab meetings, attendance of lectures and workshops, revision of manuscripts; activities aimed at acquiring: 1) theoretical knowledge about key models and thematic areas related to the cognitive neuroscience of action and perception, cortico-cortical connectivity, neural plasticity, behavioral and neurophysiological evaluation of motor and visual functions; 2) skill for designing and conducting scientific research projects, data analysis and use of advanced image-guided TMS protocols, including TMS-EMG and TMS-EEG co-registration and ccPAS; 3) writing and oral communication skills for scientific dissemination; 4) skills for translation of scientific knowledge into the development of novel rehabilitation programs.

Project activities: literature review to acquire relevant theoretical knowledge and to define stimulation parameters and behavioral procedures, recruitment of participants with the aid of master students and PhD candidates, execution of pilot studies to assess the duration of experimental sessions and participant's compliance, data collection and analysis, writing of a draft of the main findings to be submitted to a scientific journal and research dissemination at national/international congresses.

The project supervisor
Prof. Alessio Avenanti