TITLE: Neuromodulation and neurofeedback of inter-hemispheric dynamics as tools to rehabilitate and potentiate high-level cognitive functioning.

ABSTRACT:

Interhemispheric interactions, even at rest, predict individual differences in multiple cognitive domains, including attentional and executive functions, both when accounting for performance variability in healthy individuals (Ambrosini & Vallesi, 2016) and when explaining impairment in brain lesion patients (Siegel et al., 2016). Since resting activity may be a relevant prior of future task-related brain dynamics and performance, especially under higher cognitive demands (Zou et al., 2016), a promising approach could be that of using neurofeedback and neurostimulation to shape inter-hemispheric resting activity in ways that may promote an amelioration of cognitive functioning in brain damaged patients. Rehabilitation procedures with neurostimulation targeting inter-hemispheric dynamics after lesions in the motor cortex show promising results (Volz et al., 2016). Further investigations are necessary to understand the generalizability of these results to the rehabilitation of more complex executive functions involving cohesive fronto-parietal networks. Moreover, little is known about how similar or even more effective results could be obtained by using neurofeedback to re-equilibrate the inter-hemispheric imbalance underpinning behavioral deficits. The present project aims to set up theory-driven rehabilitation protocols to promote adaptive neuroplasticity supporting executive functioning, by means of both neurostimulation and neurofeedback procedures in brain lesion patients. It also aims to devise neurocognitive enhancement protocols in healthy individuals, including older adults or elite athletes.

REFERENCES:

- Ambrosini E, Vallesi A (2016) Neuroimage, 24: 843-857
- Siegel JS et al. (2016) Proc Natl Acad Sci U S A, 113: E4367-76.
- Volz LJ et al. (2016) Cerebral Cortex, 26: 2882-2894.
- Zou Q et al. (2013) Hum Brain Mapp 34: 3204-15.

PARTICIPANTS (PI and co-PIs):

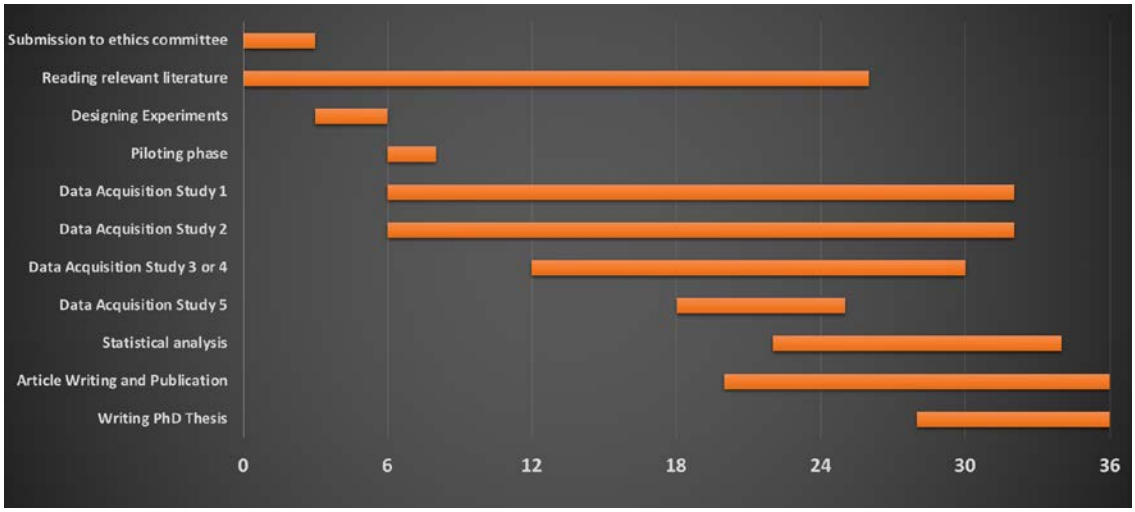
Antonino Vallesi.
Co-PI: Dante Mantini (including a period abroad).
Other potential collaborators on selected projects: Ettore Ambrosini, Alessandro Angrilli, Alessandra Bertoldo, Patrizia Bisiacchi, Annachiara Cagnin, Maurizio Corbetta, Domenico D'Avella, Carlo Semenza.

EXPERIMENTAL DATA:

To be acquired	Data concerning the efficacy and specificity of neurofeedback (EEG/MEG) and neurostimulation (TMS) procedures to enhance behavioral performance in patients and healthy individuals.
Already acquired (ready to be used)	Various datasets of resting-state and task-related EEG and fMRI data accompanied by performance data on healthy participants on a variety of executive function tasks.

If data need to be acquire, please provide a brief description of the Experimental setup, methods, instruments and scheduling (e.g. # of subjects, images/signals…): max 300 words

Groups of stroke and/or tumor patients with lateralized brain lesions, mainly affecting fronto-parietal networks (experimental patients) or other networks (control patients) to be assessed on a battery of neuropsychological tests, including computerized executive function tasks, both before and after rehabilitative protocols (to measure baseline cognitive functioning and rehab-related improvements, respectively). Patients will be rehabilitated with (Study 1) TMS neuromodulation of possibly maladaptive inter-hemispheric dynamics (>10 sessions) or (Study 2) EEG/MEG neurofeedback targeting real-time inter-hemispheric dynamics of selective frequency bands positively or negatively associated with brain network activations. The PhD student/s will work in collaboration with the group of prof. Dante Mantini (KU Leuven), to develop and/or implement methods to extract real-time estimates of neural activity in a preselected brain region, by using high-density EEG systems.
As the rate of patient recruitment is highly variable and impossible to be predicted a priori, an interconnected plan B, to be conducted in parallel to the patient work, is to conduct similar studies with healthy individuals across the entire adult lifespan (Study 3 or 4 with TMS or neurofeedback) and with special populations that might benefit from protocols informed by cognitive neuroscience theories and aimed at neurocognitively enhancing performance, such as elite athletes (Study 5).
Learning objectives: the prospective PhD Students working on this project will learn and develop theories of anatomo-functional organization of executive functions and will master the methodology for the behavioral sciences including skills such as design of experiments, submissions of proposals to local ethics committees, neuromodulation and electrophysiological techniques including TMS, EEG (and possibly fMRI), and statistical analysis.
Interdisciplinarity: the project will be highly interdisciplinary as it involves neuropsychology, electrophysiology, neuroimaging, neurology, neurosurgery, bioengineering and statistics.
A Gantt chart of possible planned activities (in months) is displayed below:



ETHICS COMMITTEE:

Obtained	
X Conditioned submission*	Expected time response (in months): 3
Not required	

* request will be submitted only if a PhD student will be associated to the project