1. Working Module topic

Non-Invasive Brain Stimulation (NIBS): an application of electromagnetic fields in neuroscience

2. Working Module description

It is now well known that the neural tissues can be excited by non-invasive techniques based on the direct injection of electric currents through the scalp or by exposure of the brain to magnetic fields. After 34 years from the pioneering paper of Merton and Morton in 1980, Non-invasive Brain Stimulation (NIBS) is now considered an elective tool for the diagnosis of central motor pathway damages, for neurorehabilitation from brain injuries and a treatment option for pain, psychiatric, and neurodegenerative disorders.
However, after three decades, there are still NIBS issues to be addressed and understood (e.g., the mechanisms of excitation of the neural fibers stimulated by an electric field of exogenous origin or the focusing and control of the electric field inside the brain tissues).
This WM aims to address these problems, boosting the NIBS scientific and technical developments. It will enabling early career researchers and leading experts in physics, engineering, mathematical modeling and basic/clinical neurophysiology to exchange information and expertise on non-invasive brain stimulation techniques.

3. Comprehensive review (state-of-the-art)

The application of exogenous electrical stimuli or time-varying magnetic fields to induce electrical currents in the nervous tissue is now well known to be able to modulate neuronal activity. That technique was initially used only for diagnosis of the central nervous systems, but it recently emerged as an intervention allowing to study the brain activity and connectivity. This has generated innovative opportunities for therapy, rehabilitation from neurological diseases and progress in the knowledge of the mechanisms of the human brain.
The two principal stimulation technologies, Transcranial Magnetic Stimulation (TMS) and transcranial electric stimulation (such as transcranial Direct Current Stimulation tDCS) induce changes in cortical excitability, which duration is longer than the stimulus itself.

4. Gaps, challenges and objectives to be achieved

The principal gaps in knowledge are:

- Mechanisms of excitation of the neural fibers in the brain stimulated by an electric field of exogenous origin;
- Techniques for focusing and control of the electric field inside the brain tissues;
- Lack of harmonized stimulation protocols for the various applications;
- Difficulty in modulated NIBS towards personalized health care;
- Need of large scale clinical trials on the various NIBS techniques and treatment.

The main objective of this WM is to address some or all the previously listed gaps in knowledge.

5. Proposed research activities

The more urgent research activities can be identified in:

- Understanding of neurobiological mechanisms and NIBS effects, through improved investigation of the link between NIBS effects on brain functions and brain disorders;
- Technical improvement of NIBS devices and systems, that should be better tailored as a function of the neurological application and need;
- Development of techniques for improving the focusing and controlling capability of the NIBS systems, particularly of Transcranial magnetic stimulation devices;

This WM will provide the needed platform for coordinating and boosting common activities among different groups participating to this COST Action, organizing at first meetings to discuss the main needs and to define a priority list for research. Moreover, research activities will be also performed through the involvement of early-stage researchers by activation of a significant number of STSM.

6. Relevant Literature

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