Consiglio Nazionale delle Ricerche
Istituto di Elettronica e di Ingegneria dell'Informazione e delle Telecomunicazioni

Cerebellar and spinal neuromodulation by transcutaneous current stimulation: from basic science to technical progress and clinical applications

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Working Module Proposal for WG2

COST Action BM1309 EMF-MED - European network for innovative uses of EMFs in biomedical applications

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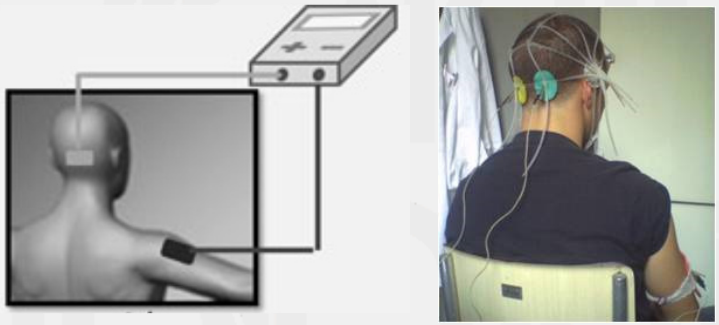
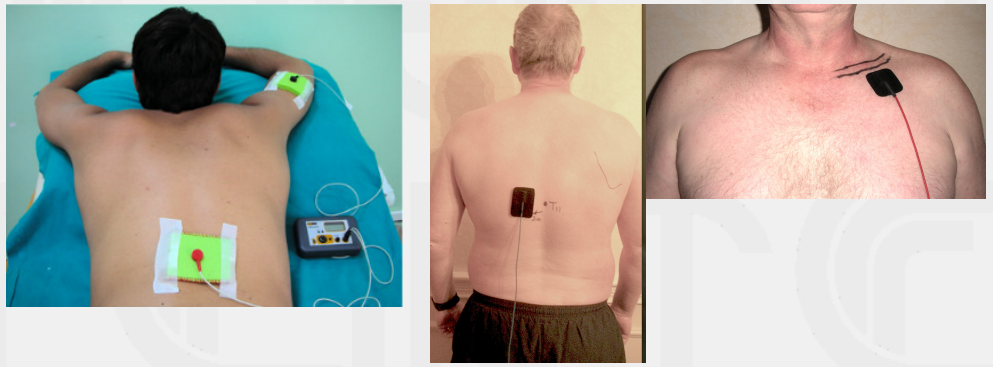
WM - Topic

Transcranial cerebellar direct current stimulation (cerebellar tDCS)
and
transcutaneous spinal cord direct current stimulation (tsDCS)
are two innovative neuromodulatory techniques based on applying low amplitude direct current (up to 2-3 mA) non-invasively through electrodes placed over the skin

Treatment duration: up to 20/25 minutes



Example of electrode montages for cerebellar tDCS: active electrode(s) over the cerebellum and reference over right arm



Example of electrode montages for tsDCS: i) active electrode over the T10 and reference above right arm; ii) active electrode 2 cm left to T11 and reference at infraclavicular area

WM - Aims

This WM aims

- ✓ to boost the advance of these two neuromodulatory techniques by generating fora to discuss specific issues on experimental and clinical research and modeling
- ✓ to facilitate the translation from basic neuroscience, scientific developments and technical progresses into clinical and therapeutic applications.
- ✓ to prioritize involvement of early-stage researchers
- ✓ to encourage cross modal interaction between groups

Cerebellar tDCS: state-of-the-art

Experimental Studies

In <u>healthy subjects</u> cerebellar tDCS could modulate:

- cerebellar motor cortical inhibition, gait adaptation, motor behaviour, and cognition (learning, language, memory, attention)

In <u>patients</u> with cerebellar disorders cerebellar tDCS

- has reported preliminary beneficial effects

[Priori A et al., 2014; Ferrucci R & Priori A 2013]

Modeling Studies

<u>Electric Field distributions</u>

- knowledge is quite limited (only 2 modelling studies)

[Parazzini M et al., 2014; Rahman A et al., 2014]

<u>Mechanisms of action</u>

- no precise information on where tDCS-induced changes take place (cerebellar cortex, deep nuclei, white matter) and on which cells (Purkinje cells , glial cells, ..)
- whole cerebellum or one area alone?

[Priori A et al., 2014; Ferrucci R & Priori A 2013]

Current knowledge suggest that the human cerebellum responds to cerebellar tDCS in a complex manner, possibly depending on the function studied, the task used, the electric field distribution and the stimulus duration.

tsDCS: state-of-the-art

Experimental Studies

In <u>healthy subjects</u> spinal tDCS could influence:

- the ascending and descending spinal pathways and spinal reflex excitability

In <u>patients</u> with spinal cord injuries spinal tDCS

- has reported very preliminary beneficial effects in promoting spinal cord plasticity

[Priori A et al., 2014; Cogiamanian F et al., 2012]

Modeling Studies

<u>Electric Field distributions</u>

- knowledge is quite limited (only 1 modelling studies)

[Parazzini M et al., 2014]

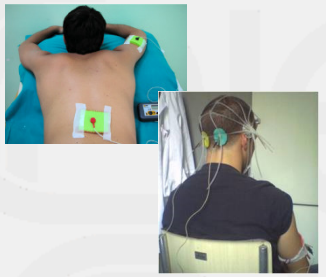
<u>Mechanisms of action</u>

- mechanisms remain speculative
- functional changes in the stimulated structure or possible trans-synaptic effects in other structures?
- neurotransmitter changes ?

[Priori A et al., 2014; Cogiamanian F et al., 2012]

Current knowledge suggest that weak DC delivered transcutaneously in humans over the spinal cord for minutes can elicit prolonged changes related to spinal functions

WM - Gaps, challenges and objectives to be achieved

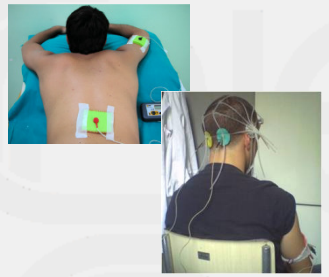


Much work remains to be done:

- ✓ Better understand the mechanisms of action
- ✓ Better characterize and validate the spatial and temporal characteristics of the electric field produced in the neural targets
- ✓ Facilitate dose design
- ✓ Evaluate safety aspect (i.e. epilepsy, use in children,..)

The main objective of this WM is to address these gaps in knowledge.

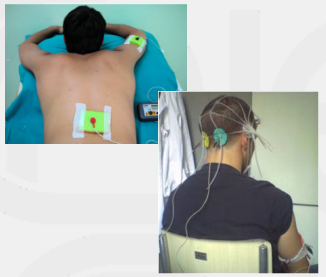
WM – Proposed Research Activities



Urgent needs :

- To compare stimulating electrode montages
- To examine how body size and age could influence results
- To study the combined effects of multiple stimulation targets.

WM – Proposed COST Implementation Activities



- Coordination of common research activities among different groups
- Organization of meetings/workshop (i.e. COST Workshop@ IEEE EMBS in Milan, on August 2015)
- Discussion on the main needs
- Definition of a priority list for research
- Activation of a significant number of STSM.