Neuromotor Rehabilitation by Neurofeedback

P. Paolo Battaglini

Bibione, 26 ottobre 2018
In order to produce movements, brain must be connected to muscles via spinal cord and nerves. If these pathways are disrupted …

… here is no way to restore communication through biology or medicine (till now)
Brain Computer Interfaces allow to **bypass** the lesion by creating an alternative pathway.
When the application is used to modulate the activity of the brain itself, it takes the name of Neurofeedback.
But what if the lesion is at the beginning?

Nor the physiological pathway or a bypass will work.
It is the case of STROKE

What it is needed, here, is an alternative source of signals
The winning card may be Neurofeedback
Why should it work?

Reorganization of the cerebral cortex after de-afferentation and de-efferentation

The activation of a region in the cerebral cortex causes increase in the EEG frequencies and consequent reduction of amplitude. It is said that the previously synchronized pattern becomes desynchronized.

This happens in the sensorimotor cortex, when the subject is requested to move.
The strategy, when movement is impaired

Motor Imagery (MI) relies on the same brain systems that are used for actual movement.

ECoG-based brain activation maps for tongue movement, imagined movement, and feedback-based BCI control of cursor (imagery of tongue movements).


We believe that MI sustained by Neurofeedback can increase rehabilitation gain in patients who have difficulty to move.
To set-up a **procedure** to find which brain regions are involved in motor imagery **and** are best modulated by neurofeedback.

To build a low cost and portable **instrument** to control the neurofeedback procedure both in the clinic and at home.

To develop a new neurofeedback **treatment** to be associated to conventional rehabilitation procedures in order to speed-up the recovery after stroke.

To achieve these objectives, we started with healthy subjects, examining the **impact of limb non-use** by means of arm immobilization, beginning from the sensorimotor cortex.
Participants: 16 right handed adults (age range: 19-25; mean age: 22; sd: 1.9)
Experimental group: 8 subjects; Control Group (no neurofeedback): 8 subjects

QUESTIONNARIES:
Edinburgh Handedness Inventory (EHI)
Movement Imagery Questionnaire-3 (MIQ3)

EEG:
10 electrodes in fronto-centro-parietal positions
(only data from the contralateral hemisphere will be reported here)
I am making the hand move by imaging related sensations.
Protocols

**EXPERIMENTAL GROUP**

**PHASE 1**
- PRE TEST
- EHI
- MIQ3

**PHASE 2**
- HAND IMMOBILIZATION

**PHASE 3**
- POST IMMOBILIZATION
- EEG: ERD/S MOTOR IMAGERY

**PHASE 4**
- NEURO FEEDBACK
- 3 BLOCKS OF 25 TRIALS

**PHASE 5**
- POS TEST
- MIQ3

90 min | 24 h | 15 min | 20 min | 45 min

**CONTROL GROUP**

**PHASE 1**
- PRE TEST
- EHI
- MIQ3

**PHASE 2**
- HAND IMMOBILIZATION

**PHASE 3**
- POST IMMOBILIZATION
- EEG: ERD/S MOTOR IMAGERY

**PHASE 4**
- NEURO FEEDBACK
- OBSERVATION

**PHASE 5**
- POST TEST
- MIQ3

90 min | 24 h | 15 min | 20 min | 45 min

MOVEMENT OBSERVATION
(the hand freely moved in the screen and the subject mentally counted the number of its movements)
Effect of hand immobilization on MI

(Time frequency plots, contralateral electrodes, all experimental subjects, mean values)

PHASE 1
PRE-IMMOBILIZATION
High beta desynchronization
Poor alpha synchronization

PHASE 3
POST-IMMOBILIZATION
(no neurofeedback)
Less beta desynchronization
More alpha synchronization
Effect of neurofeedback on MI

PHASE 3
POST-IMMOBILIZATION
(no neurofeedback)
Less beta desynchronization
More alpha synchronization

PHASE 5
POST-IMMOBILIZATION
(neurofeedback)
Higher beta desynchronization
Poor alpha synchronization

(Time frequency plots, contralateral electrodes, all experimental subjects, mean values)
A new easy-to-use NF procedure for limb rehabilitation has been developed and it is:
- not expensive
- portable

16 channels amplifier: OpenBCI (about 1.200 €)
19 electrodes CAP: SpesMedica (about 500 €)

Custom software: A.M. (to be patented)

Custom video
Conclusions

Immobilization of the hand induces rapid effects

Motor imagery reverts the effects of hand immobilization
Conclusions

A first prototype of the hardware is working in Isola

A second prototype has been ordered in Trieste

A third one is going to be ordered in Jesolo

Operators are under training in Isola and Jesolo

Four patients were seen in Isola (none of them is performing neurofeedback)

Preliminary results have been presented at the meeting “New Insight into Stroke” of the Neurological Society of Slovenia and a related short paper has been published in a dedicated book.
Who really worked

Joanna Jarmolowska¹, Marco Colussi², Aleksandar Miladinović³

¹ Science and Research Centre, Koper, Slovenia
² Department of Life Sciences, University of Trieste, Italy
³ Department of Engineering and Architecture, University of Trieste, Italy

THANKS FOR THE ATTENTION
Grazie per l’attenzione!
Hvala za pozornost!

Website:  http://ita-slo.eu/it/memori-net
          http://memorinet.eu