Interreg
ITALIA-SLOVENIJA
UNIONE EUROPEA
EVROPSKA UNIJA
MEMORI-net
Progetto standard co-finanziato dal Fondo europeo di sviluppo regionale
Standardni projekt sofinancira Evropski sklad za regionalni razvoj

Network per la riabilitazione mentale e motoria dell'ictus
Združenje za kognitivno in gibalno rehabilitacijo po možganski kapi

# Neuromotor Rehabilitation by Neurofeedback

P. Paolo Battaglini

Bibione, 26 ottobre 2018

BRAINEW Project

UNIVERSITÀ DEGLI STUDI DI TRIESTE
REGIONE DEL VENETO
ULSS4 VENETO ORIENTALE
SPLOŠNA BOLNIŠNICA IZOLA
OSPEDALE GENERALE ISOLA
ZRS
SISSA

B.R.A.I.N.
CENTRE FOR NEUROSCIENCE

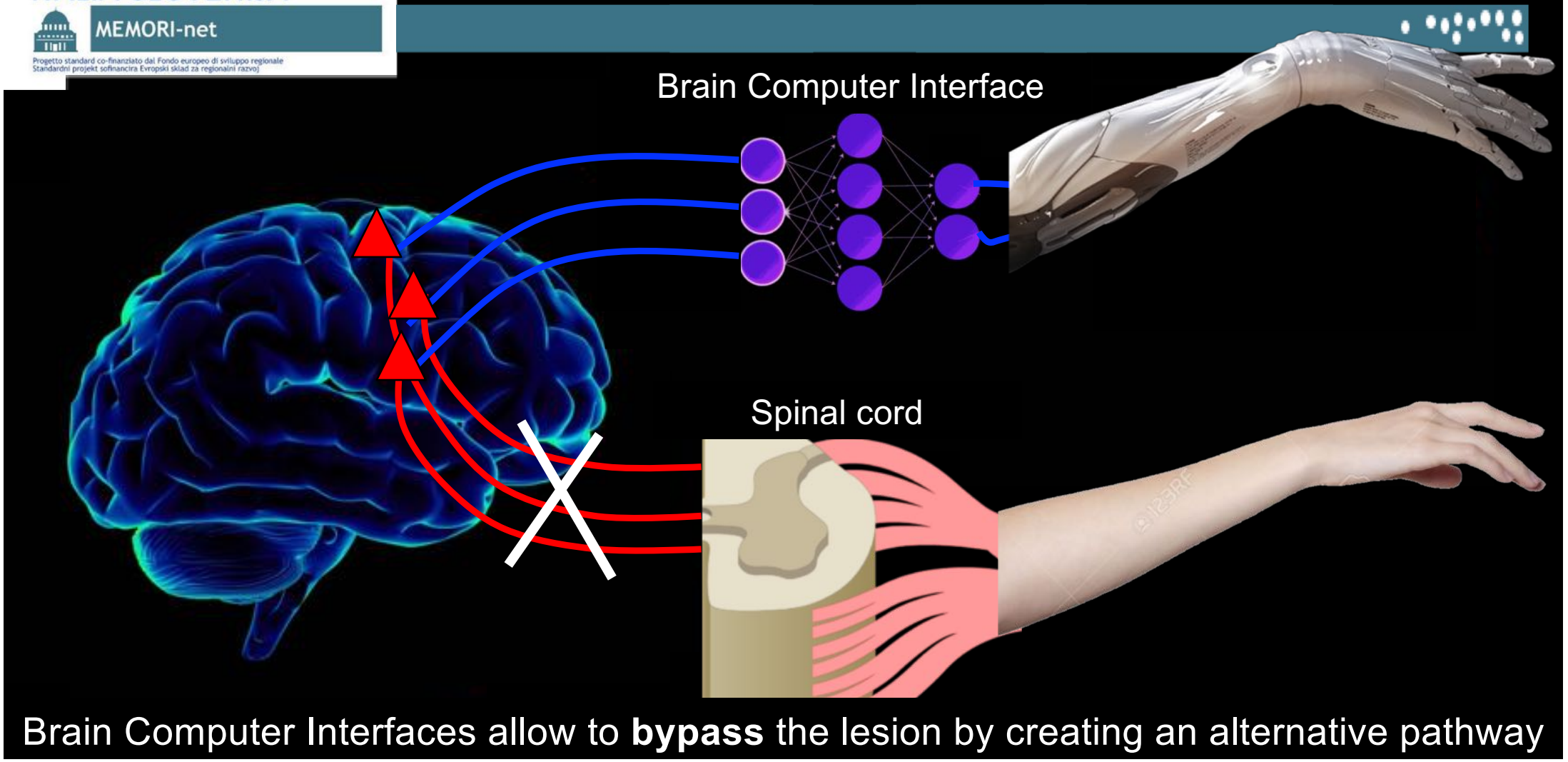
# The problem

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)

Interreg
ITALIA-SLOVENIJA
UNIONE EUROPEA
EVROPSKA UNIJA
MEMORI-net
Progetto standard co-finanziato dal Fondo europeo di sviluppo regionale
Standardni projekt sofinancira Evropski sklad za regionalni razvoj

# What can it be done?




Brain Computer Interfaces allow to **bypass** the lesion by creating an alternative pathway

Interreg
ITALIA-SLOVENIJA
UNIONE EUROPEA
EVROPSKA UNIJA
MEMORI-net
Progetto standard co-finanziato dal Fondo europeo di sviluppo regionale
Standardni projekt sofinancira Evropski sklad za regionalni razvoj

# Brain-computer interfaces

ACQUISITION OF THE SIGNAL

ANALYSIS
IDENTIFICATION
CLASSIFICATION

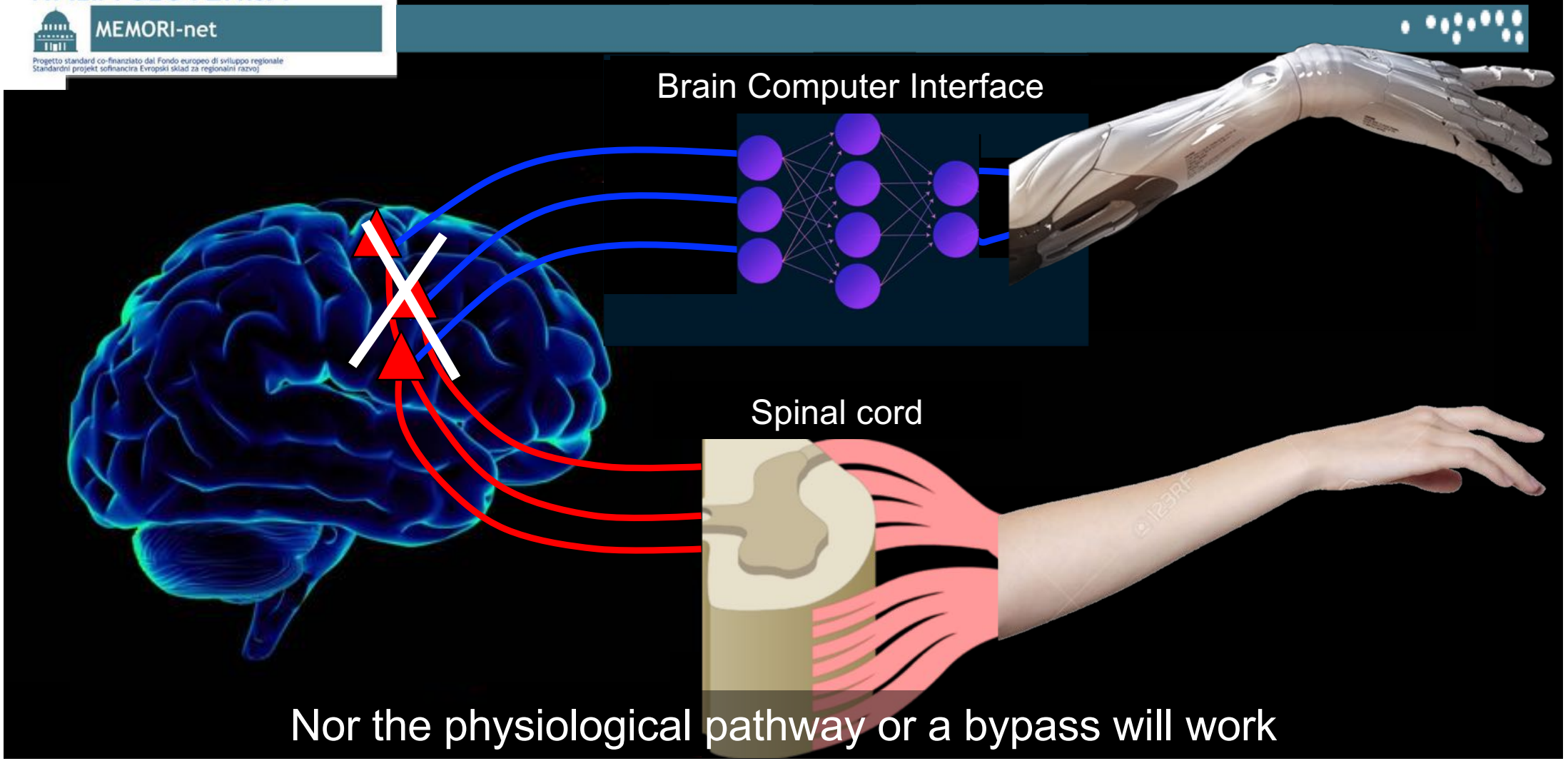
APPLICATIONS



When the application is used to modulate the activity of the brain itself, it takes the name of **Neurofeedback**

Interreg
ITALIA-SLOVENIJA
UNIONE EUROPEA
EVROPSKA UNIJA
MEMORI-net
Progetto standard co-finanziato dal Fondo europeo di sviluppo regionale
Standardni projekt sofinancira Evropski sklad za regionalni razvoj

# But what if the lesion is at the **beginning**?




Nor the physiological pathway or a bypass will work

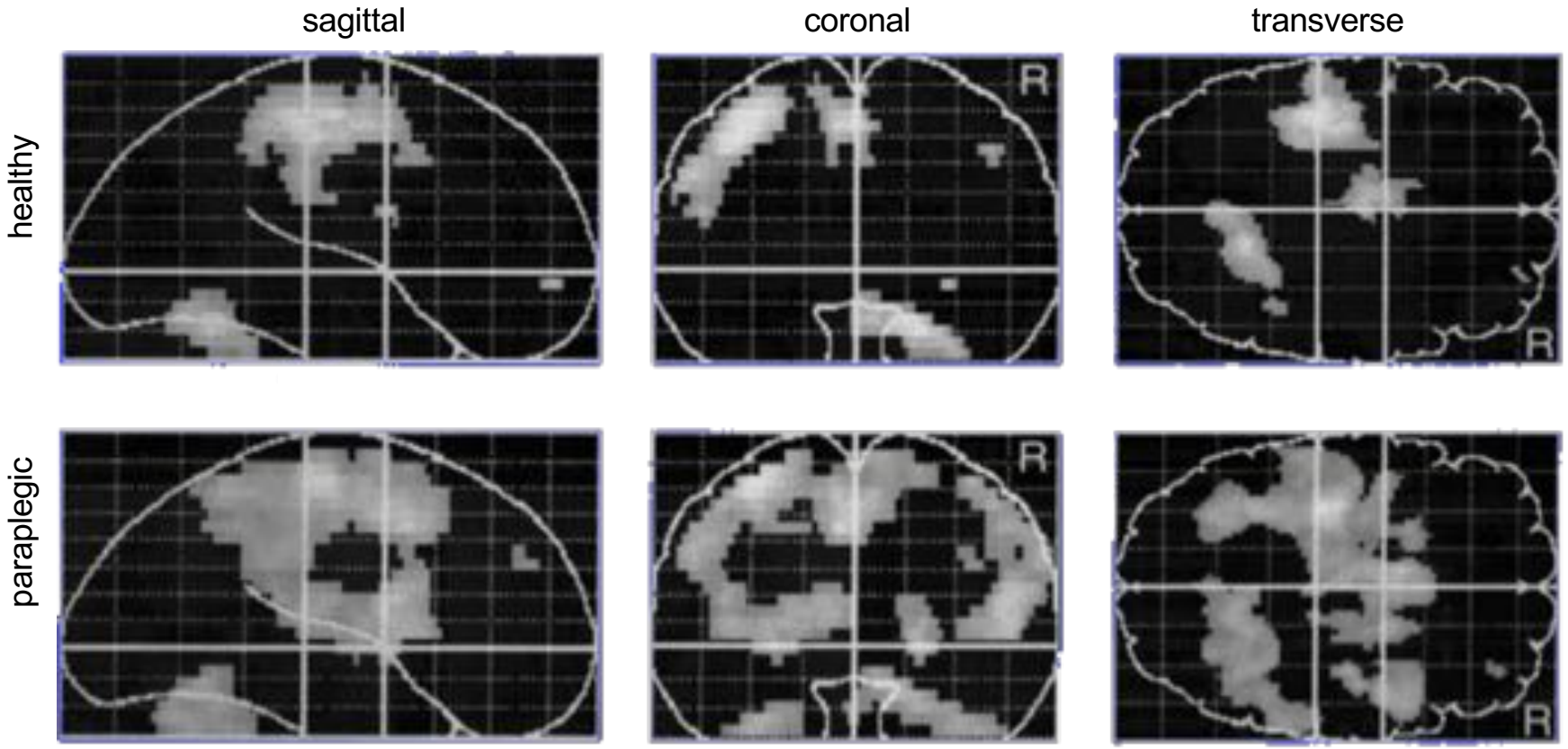
# It is the case of STROKE

Interreg
ITALIA-SLOVENIJA
UNIONE EUROPEA
EVROPSKA UNIJA
MEMORI-net

# The winning card may be Neurofeedback

# Why should it work?

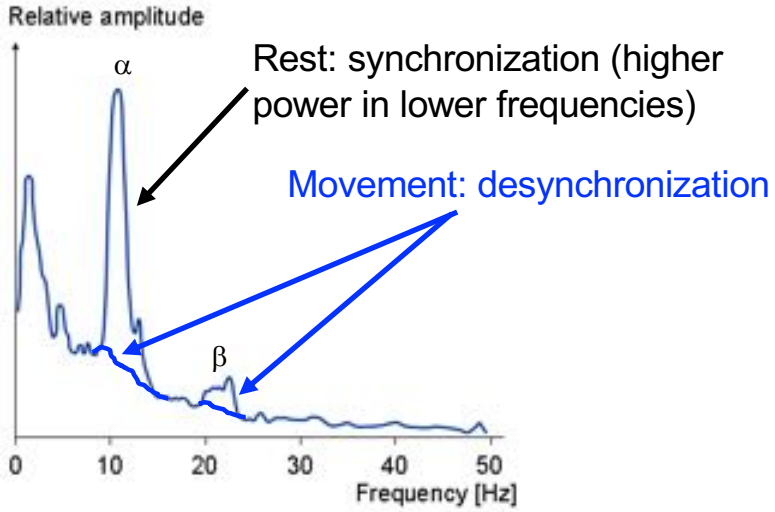
## Reorganization of the cerebral cortex after de-afferentation and de-efferentation

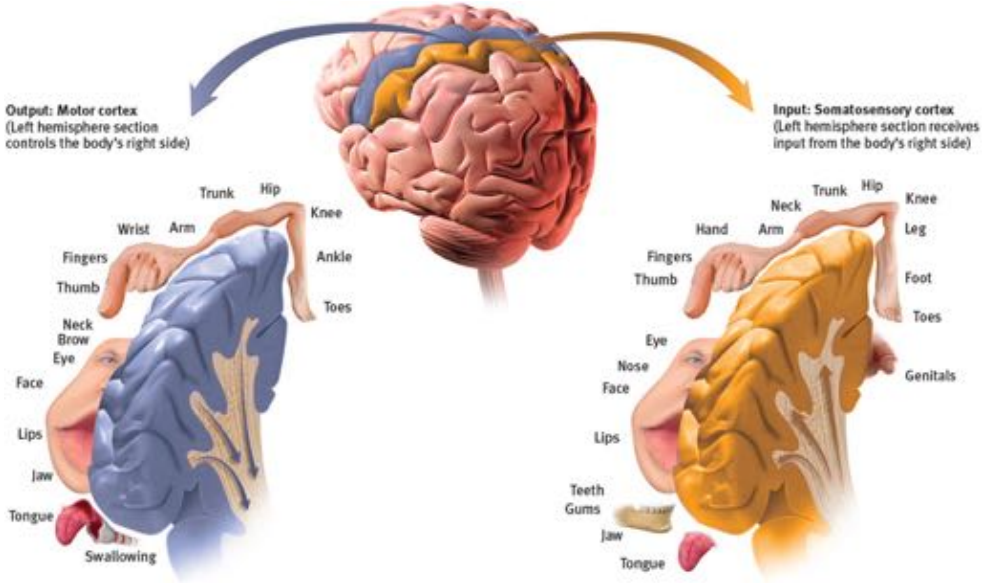



PET activation during the movement of a joystick with the right hand *Modified from Bruehlmeier et al., Eur. J. Neurosci., 10 :3918-3922, 1998*

# Which brain signals may be used?

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.

MOVEMENT IMAGERY NEUROFEEDBACK

ECoG-based brain activation maps for tongue movement, imagined movement, and feedback-based BCI control of cursor (imagery of tongue movements).
*Modified from Miler KJ, Schalk G, Fetz EE, Nips M, Ojemann JG, Rao RP (2010). Cortical activity during motor execution, motor imagery and online-based imagery feedback. Proc Nat Acad Sci USA 107:4430-5*

We believe that MI sustained by Neurofeedback can increase rehabilitation gain in patients who have difficulty to move.

Interreg ITALIA-SLOVENIJA
UNIONE EUROPEA EVROPSKA UNIJA
MEMORI-net
Progetto standard co-finanziato dal Fondo europeo di sviluppo regionale
Standardni projekt sofinancira Evropski sklad za regionalni razvoj

# Objectives, waiting for patients

To set-up a **procedure** to find which brain regions are involved in motor imagery and are best modulated by neurofeedback.

**1**

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

**2**

**3**

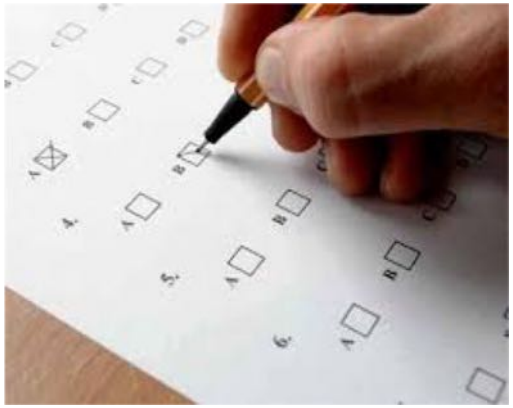
To develop a new neurofeedback **treatment** to be associated to conventional rehabilitation procedures in order to speed-up the recovery after stroke.

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.

# Methods

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:

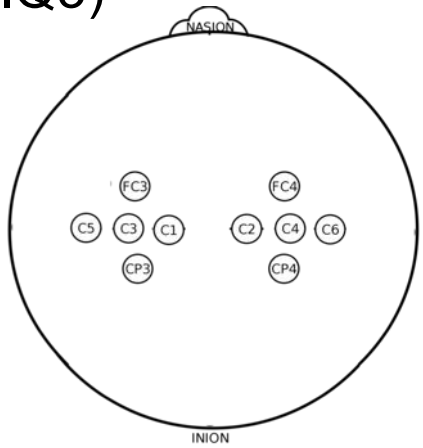
Edinburgh Handedness Inventory (EHI)

Movement Imagery Questionnaire-3 (MIQ3)

EEG:

10 electrodes in fronto-centro-parietal positions

(only data from the contralateral hemisphere will be reported here)



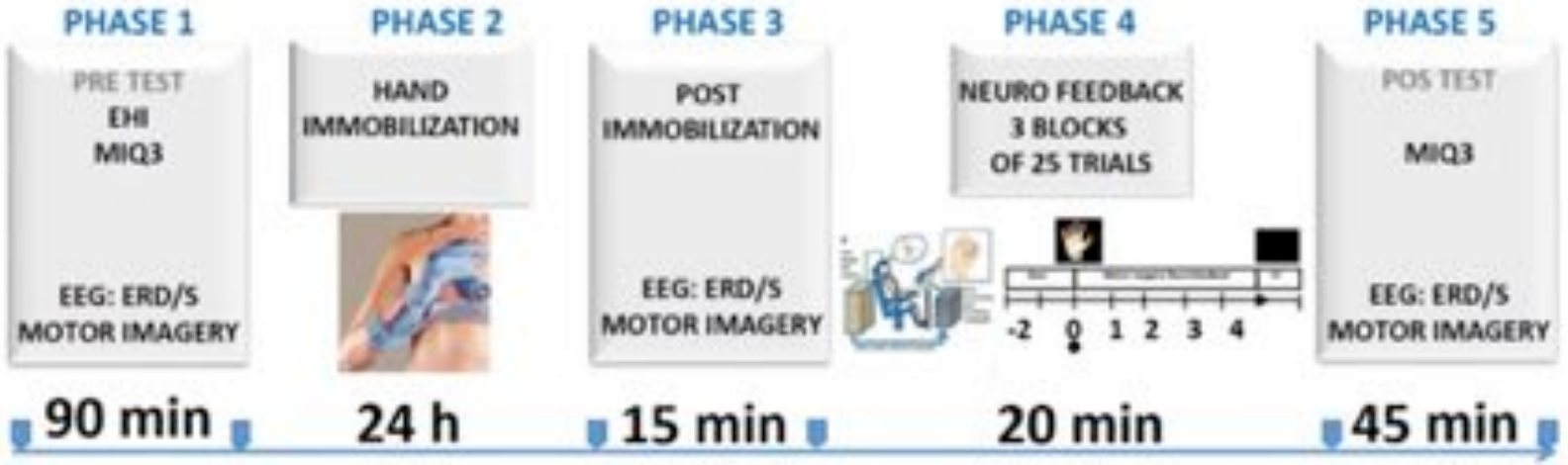
# Neurofeedback

I am making the hand move by imaging related sensations

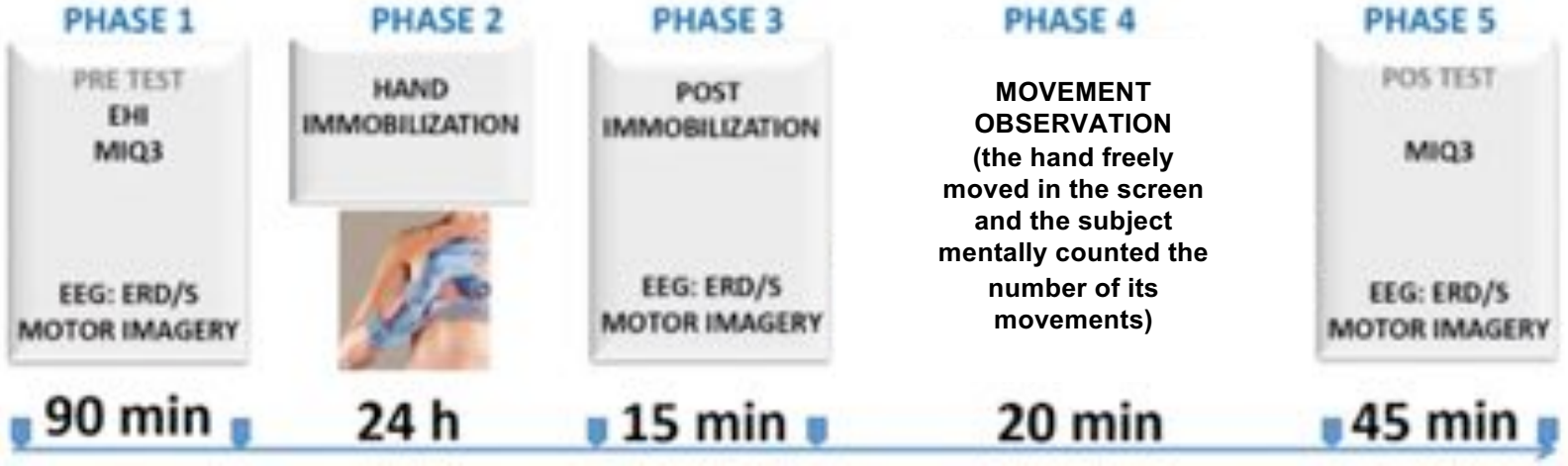
Interreg
ITALIA-SLOVENIJA
UNIONE EUROPEA
EVROPSKA UNIJA
MEMORI-net
Progetto standard co-finanziato dal Fondo europeo di sviluppo regionale
Standardni projekt sofinancira Evropski sklad za regionalni razvoj

# Protocols

## EXPERIMENTAL GROUP




## CONTROL GROUP



# Effect of hand immobilization on MI

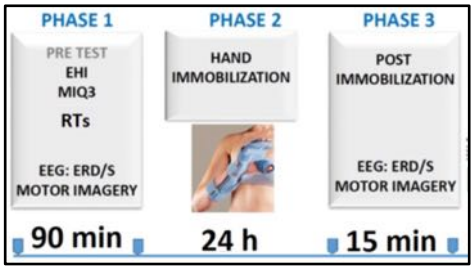
*(Time frequency plots, contralateral electrodes, all experimental subjects, mean values)*

**PHASE 1**

**PRE-IMMOBILIZATION**

High beta desynchronization

Poor alpha synchronization



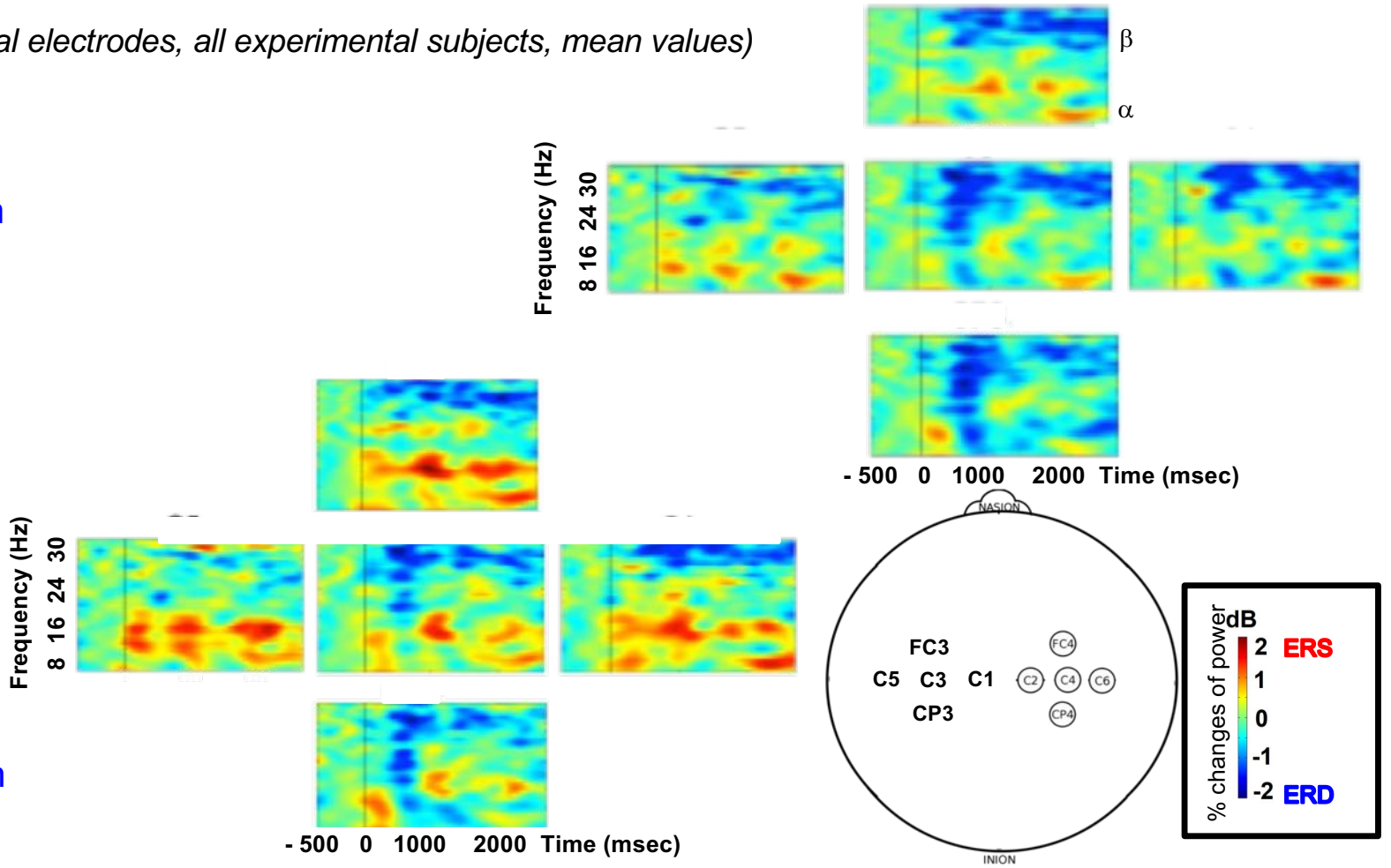

**PHASE 3**

**POST-IMMOBILIZATION**

**(no neurofeedback)**

Less beta desynchronization

More alpha synchronization



# Effect of neurofeeddback on MI

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

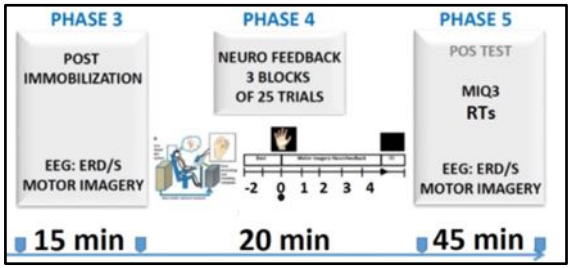
**PHASE 3**

**POST-IMMOBILIZATION**

**(no neurofeedback)**

Less beta desynchronization

More alpha synchronization



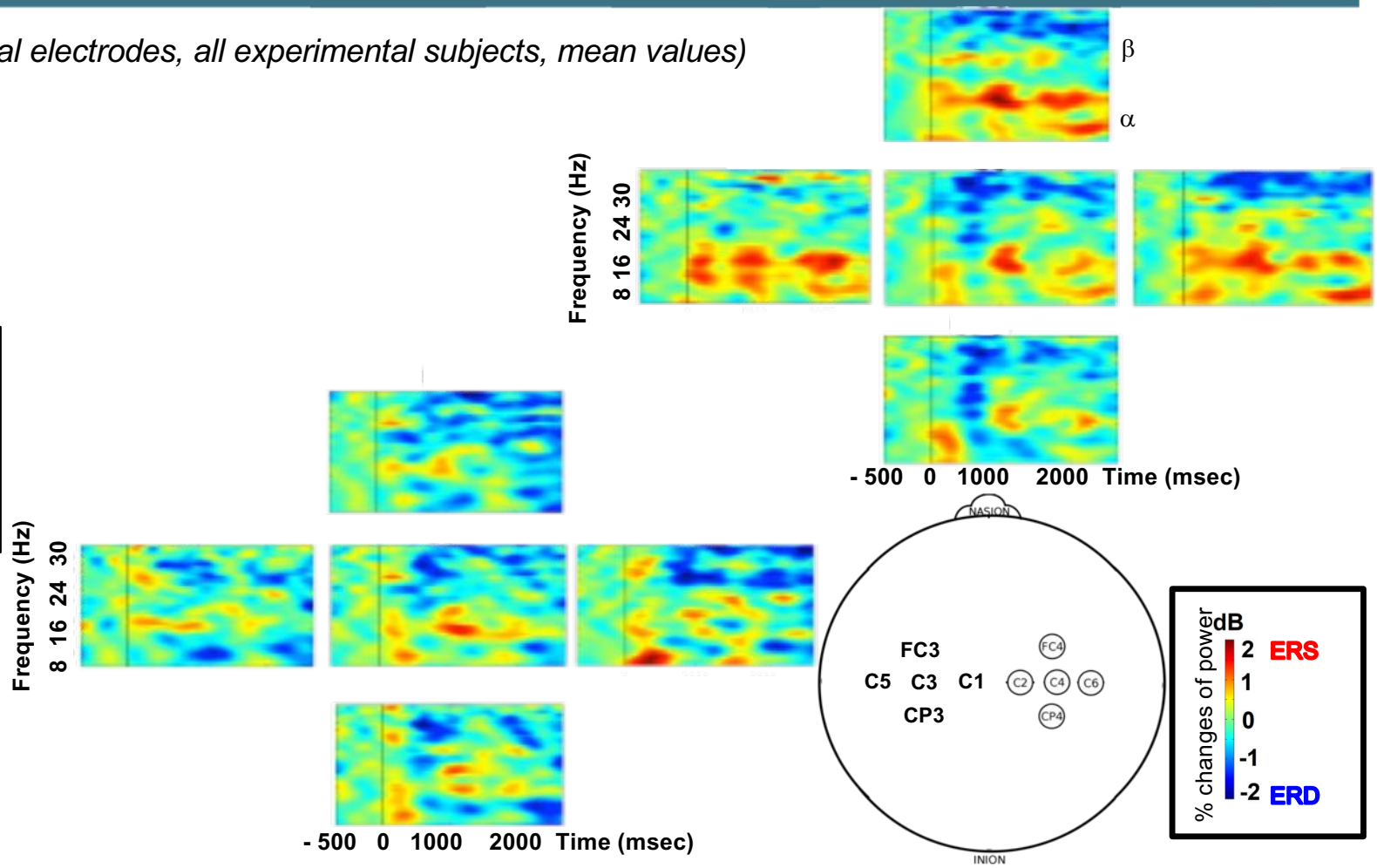

**PHASE 5**

**POST-IMMOBILIZATION**

**(neurofeedback)**

Hight beta desynchronization

Poor alpha synchronization

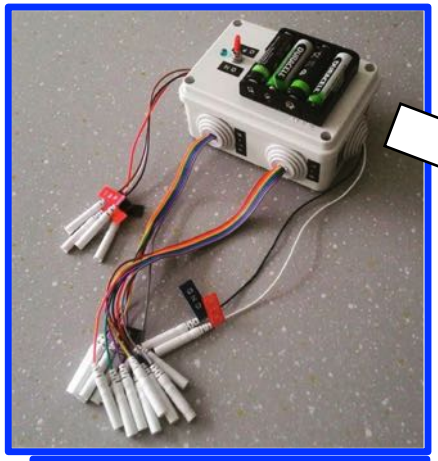


# The hardware

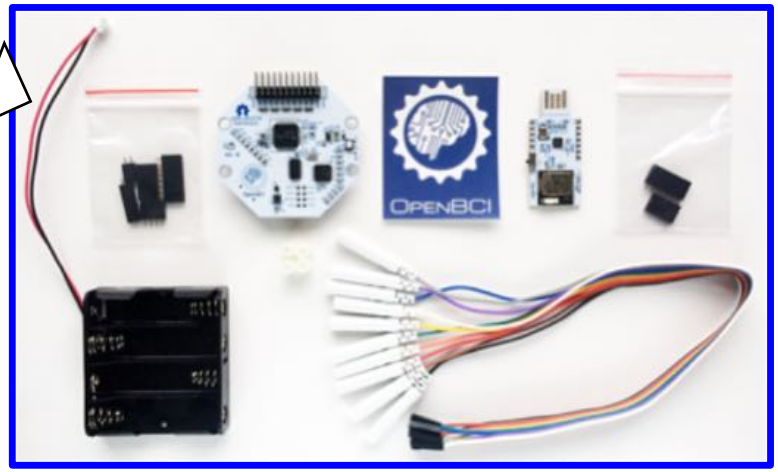
A new easy-to-use NF procedure for limb rehabilitation has been developed and it is:

- not expensive
- portable

19 electrodes CAP: SpesMedica (about 500 €)



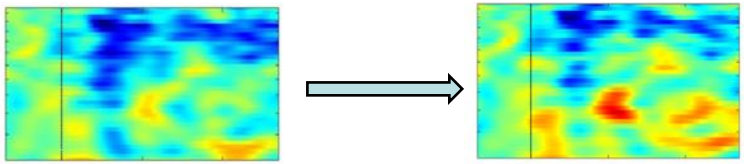
16 channels amplifier: OpenBCI (about 1.200 €)



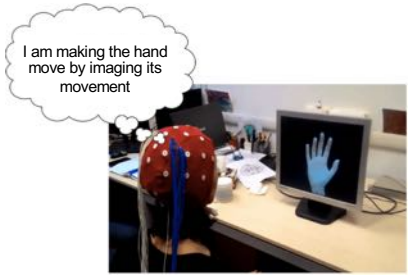

Custom software: A.M. (to be patented)

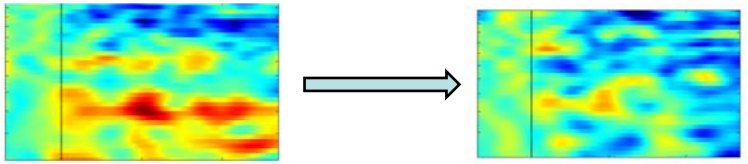
Custom video

# Conclusions



Immobilization of the hand induces rapid effects



Motor imagery reverts the effects of hand immobilization

Interreg
ITALIA-SLOVENIJA
UNIONE EUROPEA
EVROPSKA UNIJA
MEMORI-net
Progetto standard co-finanziato dal Fondo europeo di sviluppo regionale
Standardni projekt sofinancira Evropski sklad za regionalni razvoj

# 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

Interreg ITALIA-SLOVENIJA
UNIONE EUROPEA EVROPSKA UNIJA
MEMORI-net
Progetto standard co-finanziato dal Fondo europeo di sviluppo regionale
Standardni projekt sofinancira Evropski sklad za regionalni razvoj

# Who really worked

**Joanna Jarmolowska[1], Marco Colussi[2], Aleksandar Miladinović[3]**

[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

BRAINEW Project

## THANKS FOR THE ATTENTION

# Grazie per l'attenzione!
# Hvala za pozornost!

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