

# Neuroprosthetic control of an EEG-EOG BNCI system by a paralyzed patient with high spinal cord injury

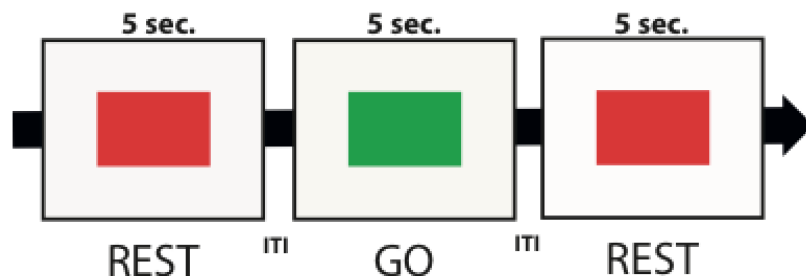
## Experimental Paradigm

This data set consists of electroencephalography (EEG) data collected from one subject with a high spinal cord lesion controlling an EEG/EOG hybrid BNCI to operate a neuroprosthetic device attached to his paralyzed right upper limb. The cue-based BNCI paradigm consisted of two different tasks, namely the 'imagination of movement' of the right hand (class 1) and 'relaxation/no movement' (class 2).

A visual signal randomly indicated the user to either close (green square) or not to move the device (red square): the two indications were given 24 times each in total separated by inter-trial intervals (ITIs) of 4-6 seconds. Each indication was displayed for 5 seconds after which the device was driven back to open position. Re-setting the exoskeleton into open position required one second.

Exoskeleton motions could be interrupted and reset to neutral position when electrooculogram (EOG) signals exceeded the EOG detection threshold. During the trials, the participants were free to use either full left or right eye movements to reset the exoskeleton.

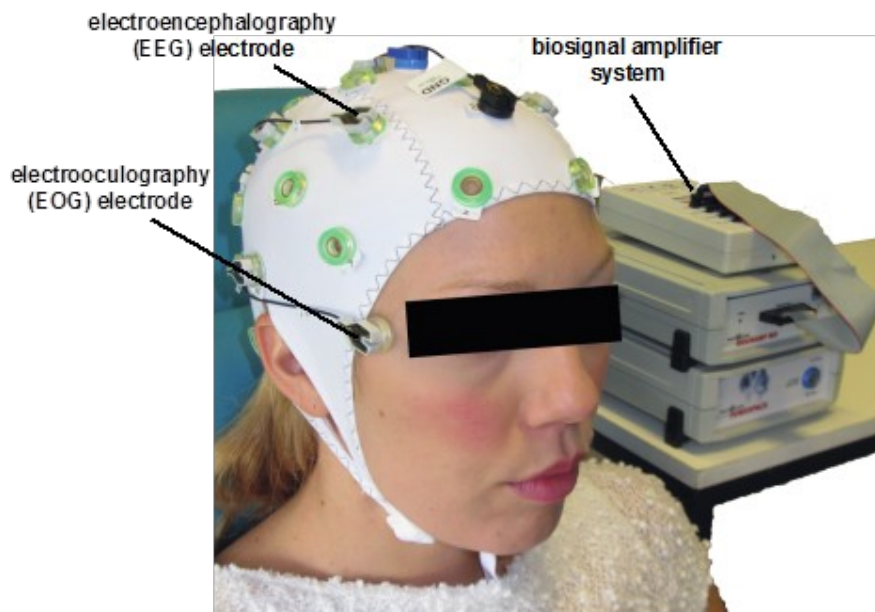
The participant was comfortably seated at a desk while EEG/EOG was recorded



*Figure 1: Timing scheme of the paradigm.*

## Data Acquisition

EEG was recorded from 5 conventional EEG recording sites (according to the international 10/20 system) using an active electrode EEG system (Acti-cap® and BrainAmp®, BrainProducts GmbH, Gilching, Germany) with a reference electrode placed at FCz and ground electrode at AFz. EEG was recorded at a sampling rate of 200Hz, bandpass filtered at 0.4-70Hz. EOG was recorded in accordance to the standard EOG placements at the left and right outer canthus (LOC/ROC). The two bipolar EOG channels were recorded at a sampling rate of 200Hz and referenced to the left and right mastoid.



**Figure 2:** *Electroencephalography (EEG) and electrooculography (EOG) were used to control a hand exoskeleton allowing for grasping motions.*

### Data File Description

The data set is saved in the Matlab format “.mat”. The data has the following structure. It consists of three different runs, each containing the following information:

data(tr).X	Raw data in the format Samples x Channels
data(tr).trial_start	Information when each trial starts in samples (24 per run)
data(tr).trial_end	Information when each trial ends in samples (24 per run)
data(tr).y	The corresponding class for each trial, either “1” or “2”
data(tr).fs	The sampling rate
data(tr).classes	Information about each class
data(tr).gender	Gender of the subject
data(tr).age	Age of the subject

Note that we only included one EOG channel because large artifacts contaminated the second channel.

### References

- Witkowski M, Cortese M, Cempini M, Mellinger J, Vitiello N, Soekadar SR. Enhancing brain-machine interface (BMI) control of a hand exoskeleton using electrooculography (EOG). *Journal of NeuroEngineering and Rehabilitation* 2014, 11:165, doi:10.1186/1743-0003-11-165.
- Soekadar SR, Witkowski M, Vitiello N, Birbaumer N. An EEG/EOG-based hybrid brain-neural computer interaction (BNCI) system to control an exoskeleton for the paralyzed hand. *Biomed Tech (Berl)*. 2014; doi: 10.1515/bmt-2014-0126 [in press].