BCI course - Project Description

Title: Control grasping degree of an exoskeleton using a Brain-Machine Interface

TA: Bastien Orset

1. Introduction

Most non-invasive BMIs based on voluntary modulations of brain rhythms aim at detecting the initiation of motor imagery (MI). Once the onset is detected, predefined commands can be triggered. Although the detection of MI initiation is critical in the process, decoding the volitional interruption of MI is of equal importance in order to endow brain-actuated devices with more natural behavior. While decoding of movement initiation is the focus of multiple works, decoding of movement termination has been barely investigated [1],[2]. Here, we investigate the use of such specific decoder for hand MI termination to detect both transitions and control the grasping degree of an exoskeleton.

2. Objectives

a) Investigate the neural correlates of MI termination and initiation.
b) Develop a BCI for decoding termination.
c) Control the degree of grasping of an exoskeleton.

3. Protocol Description

a. Paradigm 1: Delayed activation of orthosis; Day 1

Offline session

Participant is asked to perform a kinesthetic motor imagery of his right hand (MI, (i.e., imagining the feeling associated with performing a movement). A clock indicates the initiation and termination of the action (Fig. 1). After starting MI, the participant will be asked to stop it at a specific time, which is varies at each trial. Afterwards, as a source of proprioceptive feedback, the orthosis will be activated to execute a grasping action up to a certain degree based on MI duration. The experimenter will explain to the participant the way to perform kinesthetic MI. During this session, the participant will perform **4 runs of 20 trials each (4x20 = 100 trials in total)**. The structure of a trial is explained in Fig. 2. During a trial, the participant must avoid blinking and facial movements to prevent signal contamination. In between trials, a relaxation phase will allow the participant to blink and move during 3s. The runs will be cue-based, i.e. the moment when the participant needs to initiate and stop MI will be indicated.

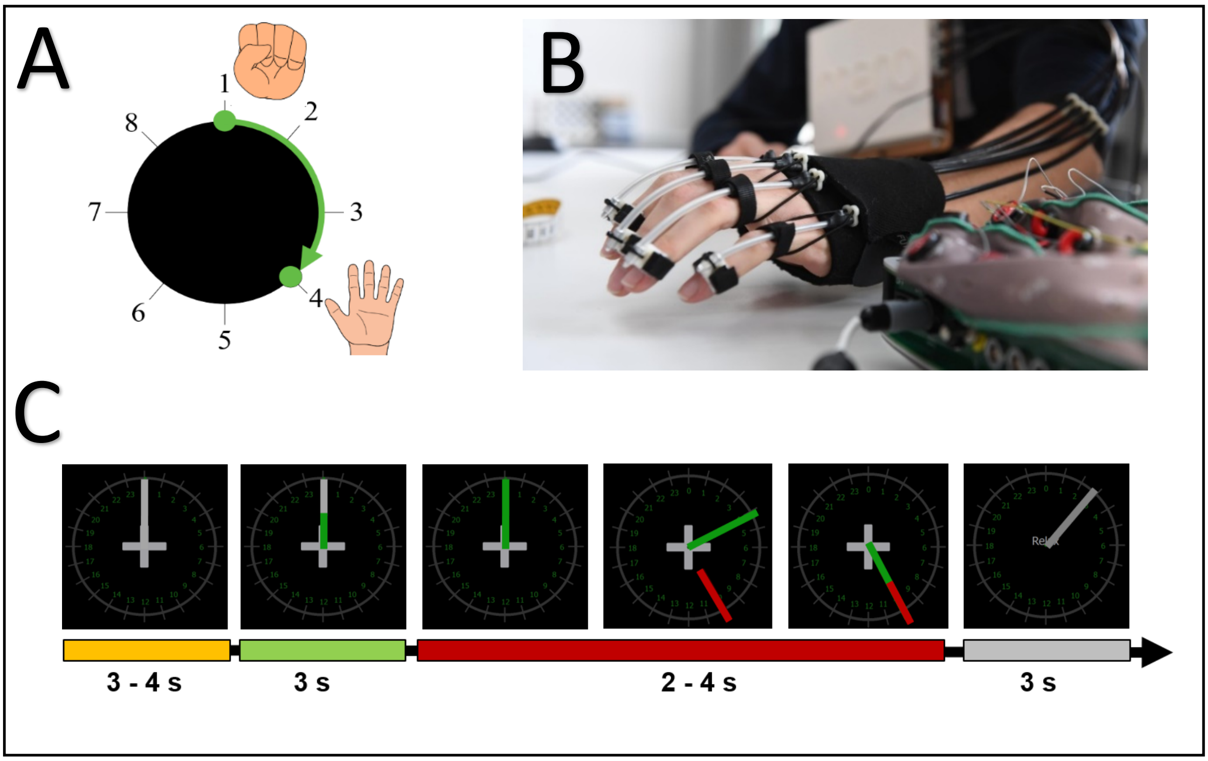

Fig. 1. **A**. Participant performs kinesthetic motor imagery (MI) of their right hand during the whole trial and stops MI when the clock hand is at a specific number. **B**. Hand orthosis used during the protocol. **C**. During a trial, the subject is asked to continuously look at a fixation cross in the center of the clock. The subject is instructed to stay calm for the first 3-4 s without moving or blinking. A clock hand (bar) indicates to the subject to initiate their MI of right hand and is filling up (green gauge) during 3 s. Once the bar is filled, the clock will move, and the subject will continue their MI from 2 to 4 sec until the clock hand reaches a target (red bar). The subject stays at rest (no blink or movement) until the clock finish its turn. A period of 3 seconds following each trial allows the subject to relax.

Online session

After training a decoder on the offline data, participants' task will be to initiate and stop the clock on a target in real-time by controlling their MI action. BMI decoders will determine if the participant want to start/stop MI and will decide accordingly to start/stop the clock. Based on their performance, and after the clock stops, the participant will receive proprioceptive feedback via the exoskeleton that will perform a grasping action congruently with the clock. The participant will perform **4 runs of 20 trials**. In this session, the aim for the participant will be to develop strategies to adapt to their individual decoder to achieve an accurate control of the clock. A feedback corresponding to the decoded user's intention will be shown under the shape of the gauge filling up. Once this gauge will be filled/emptied, the clock will start/stop moving accordingly, and the hand exoskeleton will perform the grasping action correspondingly.

b. Paradigm 2: Synchronized activation of orthosis, Days 2-3

In the last two days, we will investigate the continuous control of the orthosis. Following a similar protocol, the participant will be first trained. The offline session will be essentially identical to that of the previous paradigm, except that the exoskeleton will be activated synchronously with the clock. After a training phase, the participant will be asked to control accurately the grasping degree of the exoskeleton with MI as indicated by the clock.

4. Experimental Setting

During the experiments, we will acquire brain signal using g·tec gUSBamp. This system allows us to record brain signals from **16 active surface electrodes** placed over the sensorimotor cortex. Additionally, 2 EMG channels will record muscle activity while participant will perform MI. Each session should last around 2 hours including set-up.

5. References

[1] G. Pfurtscheller and T. Solis-Escalante, “Could the beta rebound in the EEG be suitable to realize a ‘brain switch’?,” *Clin. Neurophysiol.*, vol. 120, no. 1, pp. 24–29, 2009.

[2] O. Bai, P. Lin, S. Vorbach, M. K. Floeter, N. Hattori, and M. Hallett, “A high performance sensorimotor beta rhythm-based brain-computer interface associated with human natural motor behavior,” *J. Neural Eng.*, vol. 5, no. 1, pp. 24–35, 2008.