Neuroengineering 2023-2024

Exam October 19th, 2024

Part II

How to submit your answers.

The answers can be typed in the exam.net editor, following the template. Do not modify or move the lines containing the headers.

Textual answers must be typed in the editor. When graphical elements are required in the answer, the latter can be written on paper.

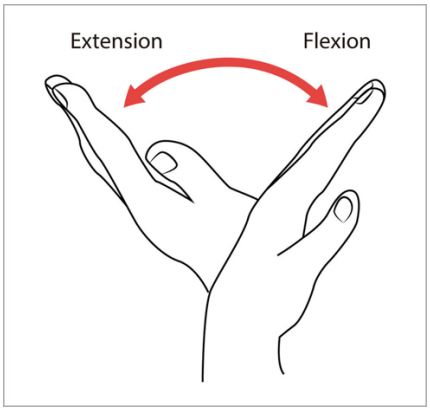
Keep your answers tidy. Messy, hard-to-read answers may penalize your mark.

The maximum total score for part II is **8**.

Carefully read the following scenario, the draft protocol in the next page and answer the questions listed below.

A team of neuroscientists is interested in studying the reactivity (change of amplitude) of spectral components of the mu rhythm when either of two motor tasks are performed by a healthy subject:

- Task A: Extension of the wrist
- Task B: Flexion of the wrist



The working hypothesis they aim to demonstrate is that significant differences (A vs. B) in the mu rhythm desynchronization induced by the subject's movement can only be appreciated if the reactivity is measured separately in the lower (8-10 Hz) and/or in the upper (11-13 Hz) alpha band separately, but not when measured in the whole alpha band.

A PhD student is tasked to draft an acquisition and analysis protocol. The resulting draft protocol is reproduced in the next page.

Questions

Write all your answers in the exam.net editor, following the provided template

Q1. (2 points) Is the commercial acquisition device adequate for the purposes of this study? Justify in max 3 lines.

Q2. (2 points) Does the proposed spectral analysis provide an adequate spectral resolution? Justify in max 3 lines, including your computation of the resolution.

Q3. (2 points) What is the number of overlapping windows from which periodograms are computed in each epoch?
Justify in max 3 lines.

Q4. (2 points) Would you suggest using a different windowing function than the one proposed in the draft protocol?
Justify in max 3 lines.

Recording and analysis protocol – First draft

Acquisition system

EEG data is acquired using Ag/AgCl electrodes positioned according to a subset to the 10-20 International System, where frontopolar, temporal, parietal, and occipital electrodes are excluded. Three more electrodes are used to provide the linked-ear reference and ground potentials.

Potentials picked up by the electrodes is fed into a commercial 8-channel biosignal acquisition device. Internally, analog signals are amplified (CMRR = 105 dB), passed through a 0.1-70 Hz analog bandpass filter, sampled 1000 times a second ([1]) and quantized into 16 bit values.

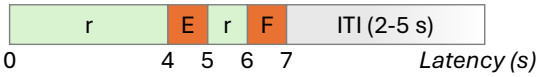
Digitized potentials are sent via a USB connection to the acquisition PC, where they are recorded to a file along with metadata (markers) describing the timing of the subject's task.

Subject task

(Number and description of subjects, subject preparation procedures and equipment for delivery of stimuli will be described in the next draft.)

1. Each trial starts with a "r" cue which stays on the screen in front of the subject for four seconds; the subject is instructed to be at rest during this interval.
2. Then a "E" cue appears on the screen for 1; the subject is instructed to extends his right wrist during this interval.
3. The "r" cue is shown again for 1 second
4. Then a "F" cue appears on the screen for 1 second; the subject is instructed to flex his right wrist during this interval.

The trial is followed by an intertrial interval, whose duration is randomized between 2 and 5 seconds.



(The number of trials and how they are split into runs will be described in the next draft.)

EEG processing

(Visual inspection and artifact rejection will be described in the next draft.)

The following 1-second-long epochs of EEG signal are extracted from each artifact-free trial (the latency range included in the epoch is reported in brackets):

Rest [1-2 s]; Extension [4-5 s]; Flexion [6-7 s].

Spectral analysis. Only channel C3 is included in the spectral analysis. For each of the three conditions (Rest, Extension, Flexion), EEG spectra are estimated using the Welch algorithm with the following parameters:

- *Window length*: 250 samples
- *Window overlap*: 50%
- *Windowing function*: Blackman-Harris

As a result, three spectral estimates are obtained, one for each condition.

(Other analyses using the remaining channels will be described in the next draft.)

Statistical analysis

(Statistical comparison of spectra will be described in the next draft.)

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[1] The sampling frequency is fixed at 1000 S/s because of external constraints and not the result of a student's choice or hardware limitations.