Neuroengineering 2019-2020

Exam 7 July 2020 – Part II

How to submit your answers.

Most answers can be typed in the Exam.net editor.
Write the answers in the same sequence as the questions (A1, A2, … B1, B2, …) and write the same headers as the test on a separate line just above your answer, e.g.:

> Problem A
> A1
> *<your answer to question A1 goes here>*
> A2
> *<your answer to question A2 goes here>*
> …

Textual answers must be typed in the editor. When graphical elements are required in the answer, the latter can be written on paper and scanned using your mobile phone at the end of the exam.
It should always be possible to use a single sheet of paper for all answers to a specific problem. Anyway, always use separate sheets of paper for problems A and B.

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

Your answers should not exceed the length recommended in each question.
Answers significantly longer than requested may reflect poor understanding of the problem, and thus will likely receive a lower mark.

The maximum total score for part II is 11.

Problem A

Carefully read the following scenario and answer the questions listed below.

The aim of an experiment is to study the neuronal basis of the **cooperation** established between **two subjects** during an interactive task in which they have to **jointly control** a cursor on the screen.

EEG recordings:

64-electrodes scalp EEG recordings are acquired **for each subject.** The two EEG systems are synchronized to allow the temporal alignment of the traces. The subjects perform **two tasks**: a **motor collaboration task**, in which they move the cursor on the screen together, and an **individualistic task**, in which each of them controls a cursor on his/her screen by him/herself. **20 trials** are recorded for each task.

Analysis performed:

1. EEG data **preprocessing;**
2. A **connectivity analysis**, to build directed brain functional networks of the two subjects' brain activities during the collaborative and individualistic tasks;
3. A **graph theoretical analysis** to extract the **Density**, the **Global Efficiency**, the **Divisibility** and the **Modularity** of the network;
4. A **classification analysis**, to discriminate the two tasks on the basis of the quantitative indices computed at the previous step.

Questions

(type the answer in the exam.net editor).

A1. *(2 points)* Indicate **which method** you would use to perform the **functional connectivity analysis**. Motivate your choice, indicating the advantages and limitations of the method selected. (Max 5 lines).

A2. *(2 points)* The indices obtained for the two tasks in a pair of subjects are reported in Table A1.

A2.1 Indicate which task is characterized by the **most efficient communication** between the nodes. Justify the answer. (Max 3 lines)

A2.2 Indicate in which task the network can be **divided in two communities**. Justify the answer. (Max 3 lines)

A1. *(1.5 points)* Given the scatter plots obtained for all the subjects, and reported in Fig. A2, indicate which features (pair of indices) you would select to perform the classification study and why. (Max 4 lines)

	Motor collaboration	Individualistic task
Density	0.41	0.38
Global Efficiency	0.31	0.53
Divisibility	0.51	0.97
Modularity	0.15	0.49

Table A1- Graph indices obtained in a pair of subjects for the motor collaboration and individualistic tasks.

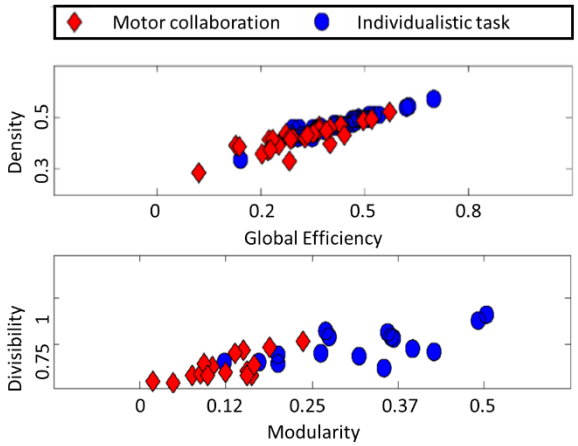

Fig. A2- Scatter plots of the four indices for the two conditions.

(problem B in the following pages)

Problem B

In each trial of an experiment, a pair of auditory stimuli is presented to an experimental subject. The ISI between stimuli in the pair is 500 ms. The ITI is 2000 ms.
The expected amplitude of the evoked components of interest is $V_{peak} \cong 20\mu V$. The standard deviation of the spontaneous EEG activity for this subject is $\sigma_{EEG} \cong 40\mu V$. We wish to obtain an averaged potential with a signal to noise ratio $SNR = \frac{V_{peak}}{\sigma_{noise}} \geq 5$

Questions:
(type all answers in the exam.net editor)

B1. *(2.5 points)* What is the minimum duration of the experiment required to obtain the specified SNR? Explain why.
Start your answer typing the duration of the experiment in minutes:seconds
Max 5 lines.

B2. *(2 points)* From *Figure B1* identify the latency and amplitude of the P50, N100 and P200 components of the potential evoked by the first stimulus of the pair (bold line). Explain the procedure you followed.
Start your answer with a line reporting the latency/amplitude pairs, such as:
P50: 45 ms, 10uV
N100: 110 ms, -22 uV
…
Justify in max 10 lines.

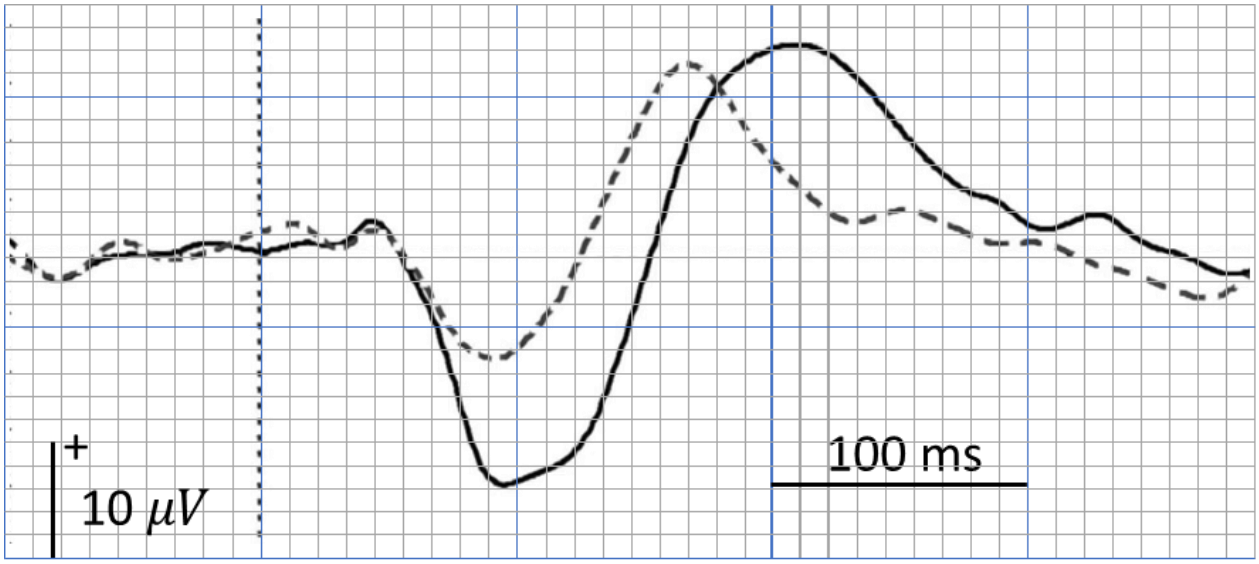

Figure B1. The averaged potential on channel Cz response showing the three main components: P50, N100, and P200. The bold line indicates the response to the first stimulus in a pair of rapidly presented stimuli (with 500 ms between stimuli). The dashed line represents the response to the second stimulus of the pair. The vertical dotted line represents the zerotime, i.e. the time of the event (first or second auditory stimulus).