

Neuroengineering 2019-2020

Exam 9 February 2021 – Part A

How to submit your answers.

Part 1.A

Type your answers in the Exam.net editor.

Write the answers in the same sequence as the questions. Use a separate line for each question. Start the line with the question number. Use dashes ('-') to indicate skipped answers. For example:

Part 1.B

1. True
2. A
3. B and D
4. ---
5. 500 ms
- ...

In the exceptional case that one or more of your answer require specific assumptions that were omitted in the question, you can add short comments at the end of each section. Start the optional comment with the number of the question it refers to. For example:

...

Comments

7. I assumed that the sinewave frequency is lower than the Nyquist frequency.

The total score will be computed summing the contribution of each answer, whose maximum partial score is shown on the right of each question, according to the following rules:

- correct and complete answer will contribute the maximum score
- partially correct or incomplete answers will contribute a fraction of the maximum score
- missing answers will not contribute
- wrong answers to the closed-ended questions (T/F, multiple choice, etc) will contribute with a negative score equal to $-(\text{max}/N)$, where N is the number of possible choices.

For instance:

- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points
- a wrong T/F answer contributes -0.25 points.

The maximum total score for part 1.B is 1.

Part 2.A

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 B
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.

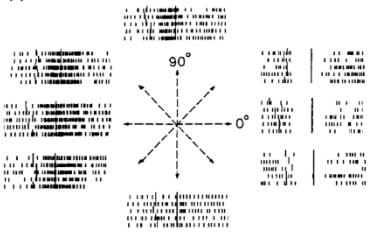
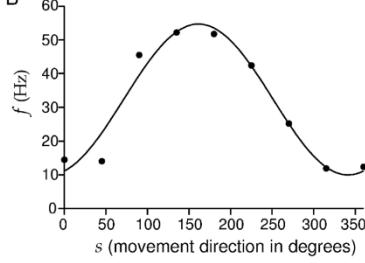
Keep your answers tidy. Messy, hard-to-read answers may penalize your mark.

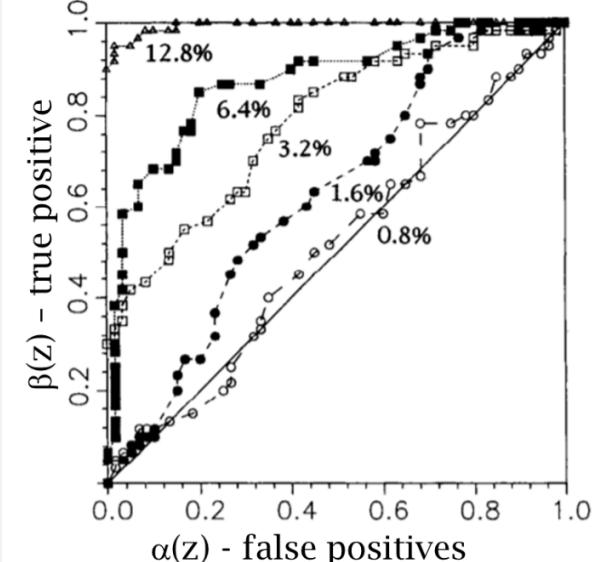
Your answers should not exceed the length recommended in each question.

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 2.B is 5.5.

For all answers: Type True/False unless otherwise specified

	Question – Section A	Points (correct)	Points (wrong)																				
1	The Na^+ voltage-gated channel is responsible for the absolute refractory period.	0.5	-0.25																				
2	We need to measure the amplitude and duration of an action potential each time it occurs to understand the cell behavior.	0.5	-0.25																				
3	The firing rate of the pre-synaptic neuron influences the amplitude of the resulting action potential in the post-synaptic cell.	0.5	-0.25																				
4	The thalamus is a cortical region.	0.5	-0.25																				
5	sEEG (stereoElectroencephalography) measures the activity in the same regions that are accessible by scalp electroencephalography (EEG).	0.5	-0.25																				
6	The frontal lobe houses the primary motor function.	0.5	-0.25																				
7	To record in vitro measures of the membrane potential over the soma of a single neural cell, you will use extracellular measures.	0.5	-0.25																				
8	One of the main advantages of scalp EEG with respect to other measures of the brain activity is its high temporal resolution.	0.5	-0.25																				
9	The EEG signal is mainly generated by action potentials.	0.5	-0.25																				
10	Given the tuning curve in the figure, obtained for a neuron of the primary motor cortex for different directions s of the arm movement (expressed in degrees): A  B  <table border="1"> <caption>Data points estimated from Figure B</caption> <thead> <tr> <th>Movement Direction (s) [degrees]</th> <th>Firing Rate (f) [Hz]</th> </tr> </thead> <tbody> <tr><td>0</td><td>15</td></tr> <tr><td>50</td><td>18</td></tr> <tr><td>100</td><td>45</td></tr> <tr><td>150</td><td>55</td></tr> <tr><td>180</td><td>52</td></tr> <tr><td>200</td><td>50</td></tr> <tr><td>250</td><td>40</td></tr> <tr><td>300</td><td>20</td></tr> <tr><td>350</td><td>12</td></tr> </tbody> </table>	Movement Direction (s) [degrees]	Firing Rate (f) [Hz]	0	15	50	18	100	45	150	55	180	52	200	50	250	40	300	20	350	12	0.5	-0.25
Movement Direction (s) [degrees]	Firing Rate (f) [Hz]																						
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200	50																						
250	40																						
300	20																						
350	12																						
	The neural response for a movement direction of 90 degrees is greater than for one of 180 degrees.																						
11	In reference to the previous figure (question 10): if I have many trials recorded for each values of s (panel A), I will build a different tuning curve for each of them.	0.5	-0.25																				
12	In reference to the previous figure (question 10): if the measured firing rate is 55Hz, I can «guess» by which movement direction that response was produced.	0.5	-0.25																				
13	In a Poisson process, the probability of an <i>isi</i> (inter spike intervals) of 60 ms is lower than that of an <i>isi</i> of 20 ms	0.5	-0.25																				
14	The difference between the distribution of <i>isi</i> in real data and in simulated data produced by a Poisson generator can be reduced by adding correcting factors to the generator.	0.5	-0.25																				

15	Given the ROC curves in the figure:		0.5	-0.25
	The related AUC can assume values between [0,1]			
16	In reference to the previous figure (question 15): the ideal curve is the one closer to the upper left corner.	0.5	-0.25	
17	The Ordinary Coherence is an estimator of causality.	0.5	-0.25	
18	The Partial Directed Coherence (PDC) is based on the spectral matrix $S(f)$ obtained by means of the Wiener-Khinchin Theorem	0.5	-0.25	
19	The Granger Index G_{xy} between two time series x and y indicates the direction of the interaction between them.	0.5	-0.25	
20	In a graph, the distance $d(i,j)$ between two nodes is given by the shortest path that links them.	0.5	-0.25	
21	In a graph, given two communities C_1 and C_2 , the Divisibility index D is directly proportional to the number of connections linking nodes belonging to different communities.	0.5	-0.25	
22	A random network has high Global Efficiency and low Local Efficiency.	0.5	-0.25	
Total points for Section A (max)		11		

Neuroengineering 2019-2020
Exam of 09 February 2021 – Part II

Problem A

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

A novel approach for the motor rehabilitation of the lower limb is tested in a group of patients with traumatic brain injury (TBI).

Before and after the intervention, the patients are subjected to a neurophysiological assessment, with the aim to evaluate the changes in the brain functional connectivity that occurred as a result of the rehabilitation.

The neurophysiological measurements are performed in two sessions: one immediately before (PRE) and one immediately after (session POST) the rehabilitative intervention (Fig. A1). During the screening, the patients perform a motor task involving the affected limb.

Questions

A1. The functional connectivity networks obtained for the PRE and POST sessions are reported in Fig. A2. (*write the answers on paper*)

- A1.1.** Extract the corresponding **adjacency matrices** (*0.5 points*)
- A1.2.** Compute the **Density** for each graph (*1 point*)
- A1.3.** Compute the **Global Efficiency** for each graph (*2 points*)

A2. Comment on the **changes** (POST vs PRE) in these indices after the intervention. Which index would you choose to quantify the effects of the rehabilitation and why? (*write the answer in the exam.net editor*) (*1 point*)

A3. If 2 of the 6 regions are subcortical and 4 are cortical, indicate **which technique** for the **acquisition** of **neuroelectrical signals** you would use, and **why**. Motivate the pro and cons of your choice. (*write the answer in the exam.net editor*) (*1 point*)

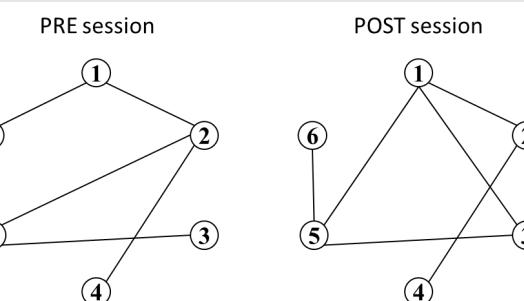
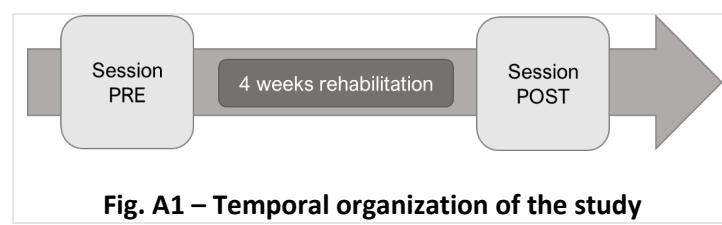


Fig. A2- Brain functional networks PRE and POST rehabilitation