Neuroengineering 2020-2021

Exam 18 June 2021 – Part I

How to submit your answers.

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:

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

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:

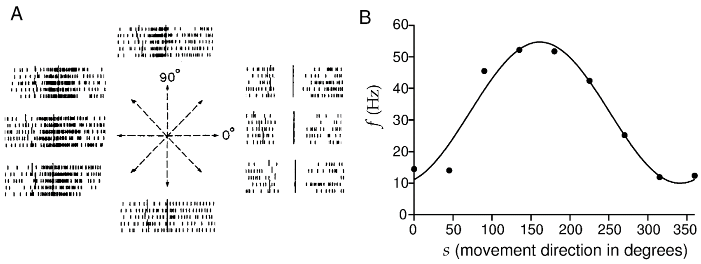
- correct and complete answer will contribute the maximum score
- partially correct or incomplete answers will contribute a fraction of the maximum score
- missing answers will not contribute
- wrong answers to the closed-ended questions (T/F, multiple choice, etc) will contribute with a negative score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

For instance:

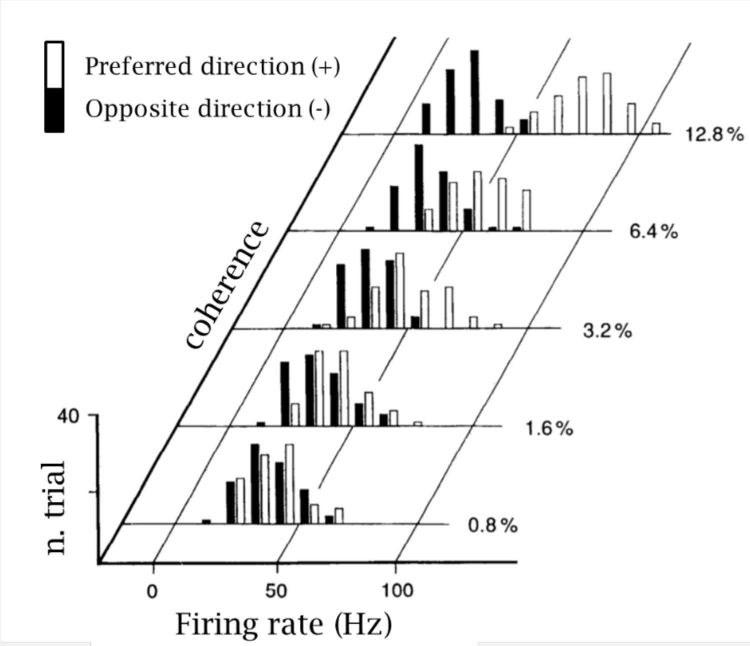
- a correct T/F answer contributes 0.5 points,
- a missing T/F answer contributes 0 points
- a wrong T/F answer contributes -0.25 points.

The maximum total score for part I is 22.

Section A

<table>
<tr><th></th><th>Question</th><th>Points (correct)</th><th>Points (wrong)</th></tr>
<tr><td>1</td><td>The voltage-gated K^+ channel inactivation state is responsible for the absolute refractory period.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>2</td><td>The voltage-gated Na^+ channel is responsible for the repolarization phase of the action potential.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>3</td><td>Temporal and spatial summation can occur simultaneously.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>4</td><td>The firing rate influences the amplitude of the resulting action potential in the post-synaptic cell.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>5</td><td>The long-term synaptic plasticity involves a structural change in the post-synaptic membrane.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>6</td><td>The brain operates at the temporal scale of milliseconds.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>7</td><td>The synchronicity of the neural activity affects the amplitude of EEG signals.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>8</td><td>Scalp EEG is mainly produced by the deep (subcortical) regions.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>9</td><td>The electrical variation of the membrane potential that mainly contributes to EEG is the action potential.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>10</td><td>The tuning curve in the figure shows (panel A) the spike trains obtained - for different trials - from a neuron of the primary motor cortex in correspondence to an arm movement, and (panel B) the firing rate f of the same neuron as a function of the angle s of the same movement direction:


When the firing rate is 55 Hz, I can infer which movement direction produced that response.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>11</td><td>In reference to the previous figure (question 10): from the curve I can conclude that this neuron is tuned to be active in correspondence to a given movement direction.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>12</td><td>In reference to the previous figure (question 10): the firing rate f in panel B was computed as the average of the neural response function across trials.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>13</td><td>In a Poisson process, when r increases, higher values of n are less likely.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>14</td><td>The difference between the distribution of isi (inter spike intervals) in real data and in simulated data produced by a Poisson generator is due to the refractory periods.</td><td>0.5</td><td>-0.25</td></tr>
</table>

<table>
<tr><td>15</td><td>Given the firing rate distribution in the figure, obtained for a neuron of the primary visual cortex in response to the motion direction of dots on the screen in two possible directions (+ and -) and with different levels of coherence:


Discriminability d’ is higher when the coherence level is equal to 1.6% than when it is equal to 6.4%.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>16</td><td>In reference to the previous figure (question 15): the distribution (+) is more affected by the coherence level than the distribution (-).</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>17</td><td>The Partial Directed Coherence (PDC) is a multivariate estimator of brain connectivity.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>18</td><td>Given the Ordinary Coherence $C_{xy}(f)$ between two time series x and y, $C_{xy}(f) \in [0, \infty]$.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>19</td><td>Given the Granger Index G_{xy} between two time series x and y, G_{xy} is a function of the frequency.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>20</td><td>In a graph, the distance $d(i,j)$ between two nodes is given by the average length of the paths that link them.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>21</td><td>In a graph, the Global Efficiency $\in [0, 1]$.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td>22</td><td>A small-world network has fewer nodes than a regular network.</td><td>0.5</td><td>-0.25</td></tr>
<tr><td colspan="2">Tot</td><td colspan="2">11</td></tr>
</table>

(continues on the following page)

For all answers: Type True/False unless otherwise specified

#	Question – Section B	Points (max)
1.	The “waxing and waning” of the alpha rhythm is a change of amplitude occurring about 10 times a second.	0.5
2.	The CMRR is usually expressed in decibel (dB) and high values characterizes better amplifiers.	0.5
3.	The difference of contact impedances of electrodes should be small compared to the input difference of the differential amplifier, otherwise the resulting unbalance compromises its common-mode rejection capability.	0.5
4.	An artifact is a potential difference due to sources outside the brain.	0.5
5.	Contact impedance of the electrodes can be measured using a direct (non-alternating) current.	0.5
6.	The EEG electrode F8 is located to the left of electrode F7	0.5
7.	An eyeblink produces an artifact which often interferes with the analysis of the beta band of the EEG.	0.5
8.	Sweating can affect the EEG, causing an increase of contact impedance and an increase of powerline noise	0.5
9.	Notch filters effectively remove powerline noise because they reject all signals above their corner frequency.	0.5
10.	The alpha rhythm is said to be synchronized when the amplitude of its oscillations increase.	0.5
11.	Synchronized averaging of N EEG trials produces N values each corresponding to the average value of the potential in each trial.	0.5
12.	Evoked brain activity is phase-locked to the stimulus to which it is a response.	0.5
13.	Event-Related Desynchronization/Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.	0.5
14.	In Analog to Digital Conversion, the Nyquist frequency equals half of the sampling frequency.	0.5
15.	Appropriate application of an analog filter (i.e. before the analog signal is converted) may prevent saturation by removing high amplitude artifacts in specific frequency bands.	0.5
16.	Quantization divides the input range of the ADC into (approximately) $NBITS$ intervals, where NBITS is the number of bits of the ADC.	0.5
17.	The RMS and the standard deviation of a zero-mean signal have the same value (assume that the number of samples $N \to \infty$).	0.5
18.	The synchronized average of N trials containing only spontaneous EEG whose $RMS_{trial} = \sigma^2$ is a signal $RMS_{avg} = \sigma^2/N$	0.5
19.	An IIR filter can be designed to have “linear phase”, so that they do not introduce time-domain distortions in the waveform of the output signal.	0.5
20.	The spectral leakage phenomenon is observed, for instance, when comparing the spectrum of a signal with the spectrum of a short section of the same signal.	0.5

#	Question – Section B	Points (max)
21	The Butterworth filter is a design method in the family of FIR	0.5
22	The amplitude of sensorimotor rhythms can be voluntarily modulated through the exercise of motor imagery, to build a cursor control based on a BCI.	0.5
	Total points for Section B (max)	**11**

(End of the test)