Neuroengineering 2019-2020

Exam 9 February 2021 – Part B

How to submit your answers.

Part B.1

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 –(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 11.

For all answers: Type True/False

#	Questions – Part B.1	Points (max)
1.	The frequency of oscillation of the beta rhythm is around 10 Hz	0.5
2.	Evoked Potentials are deflection of the EEG signal following the presentation of a sensory input.	0.5
3.	EEG electrodes made of gold allow recording of extremely slow-changing potentials.	0.5
4.	The CMRR is usually expressed in decibel (dB) and high values characterizes better amplifiers.	0.5
5.	The difference of contact impedances of electrodes should be large compared to the input difference of the differential amplifier, otherwise the amplitude of the signal would be reduced (shortcut).	0.5
6.	In monopolar EEG recordings, the reference electrode is placed on scalp position that are *assumed* to be far from the electrical sources of interest, such as the earlobes.	0.5
7.	The amplitude of the electromyogram (EMG) originated from muscles never exceed $10\ \mu V$.	0.5
8.	The powerline noise affects a very narrow frequency band of the recorded signal around 50 Hz (in Europe) and odd multiples of (150 Hz, 250 Hz, …).	0.5
9.	Movement of the subject's head may produce slow artifacts that are less pronounced when non-polarizable electrodes are used	0.5
10.	The amplitude of ERPs is measured with respect to a baseline epoch (usually preceding the stimulus), in which the amplitude is assumed to be zero.	0.5
11.	The SOA is always smaller than the ISI	0.5
12.	Brain activity in response to a stimulus can be non-phase-locked, meaning that they show variable latency (jitter) at each repetition. This activity is called *induced*.	0.5
13.	Event-Related Desynchronization/Synchronization (ERD/S) quantify relative changes of the power of the EEG rhythm in a predefined frequency range, relative to a baseline period.	0.5
14.	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of a set of $sinc()$ functions, one for each sample.	0.5
15.	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval: $\sigma_{quant} = 1/\sqrt{12}\ LSB$	0.5
16.	Appropriate application of a high-pass digital filter may prevent saturation by removing high amplitude slow artifacts.	0.5
17.	The sample variance of a signal is given by $s_X^2 = \frac{1}{N-1}\sum_i (x_i - \bar{X})^2$, where the sum extends on the N samples of the signal X	0.5
18.	In a gaussian noise, the probability density that a sample has a given amplitude value follows the normal distribution with zero mean.	0.5
19.	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

#	Questions – Part B.1	Points (max)
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
21	The Butterworth filter is a design method in the family of Finite Impulse Response filters	0.5
22	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	0.5
	Total points for Section B (max)	**11**

(Part 2.B on the following pages)

Part B.2

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

> Problem B
> B1
> *<your answer to question B1 goes here>*
> B2
> *<your answer to question B2 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.

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 B.2 is 5.5.

Problem

A P300 event-related potential (ERP) is elicited by means of a "oddball" paradigm, i.e. delivering to the subject a train of stimuli randomly chosen between two option. In this experiment, the stimuli were visual and consisted of either an 'O' or a 'X' presented on a computer screen, with the timing shown in *Figure B1(A)*. EEG potentials are recorded on three scalp electrodes, segmented into trials, and selectively averaged. The waveforms in *Figure B1(B)* correspond to the average of the 'X' stimuli only, which is presented with a probability P=20%. Also check the information embedded in *Figure B1*.

Questions:

(Type all answers in the exam.net editor. Mathematical formulas can be handwritten and a reference to the scan can be included in the text)

B1. *(1 point)* Would a high-pass filter with cutoff frequency at 30 Hz significantly affect the amplitude of the ERPs? Justify.
Start your answer with a line containing only Yes or No
Justify in max 2 lines.

B2. *(0.5 points)* Determine the latency of the P300 component on a frontal channel.
Start your answer with a line containing the latency
Describe the measurement process in max 2 lines.

B3. *(1 point)* Determine the amplitude of the P300 component on each channel. State whether the ERP more positive on the anterior or posterior part of the scalp.
In the first line of your answer report the amplitude on each channel. Use the second line for the statement.

B4. *(1.5 points)* How long would the data recording session last if we need to reduce the amplitude of the spontaneous EEG by a factor of K=10 with respect to the unaveraged trial? Justify.
Start your answer with a line reporting the duration of the recording session
Justify in max 5 lines.

B5. *(1.5 points)* Since only 20% of the trials contain a 'X' stimulus, could the experimenter increase the signal to noise ratio of the ERP by raising the proportion of X's to 80% (thus increasing the number of useful trials)? Justify.
Start your answer with a line containing only Yes or No
Justify in max 5 lines.

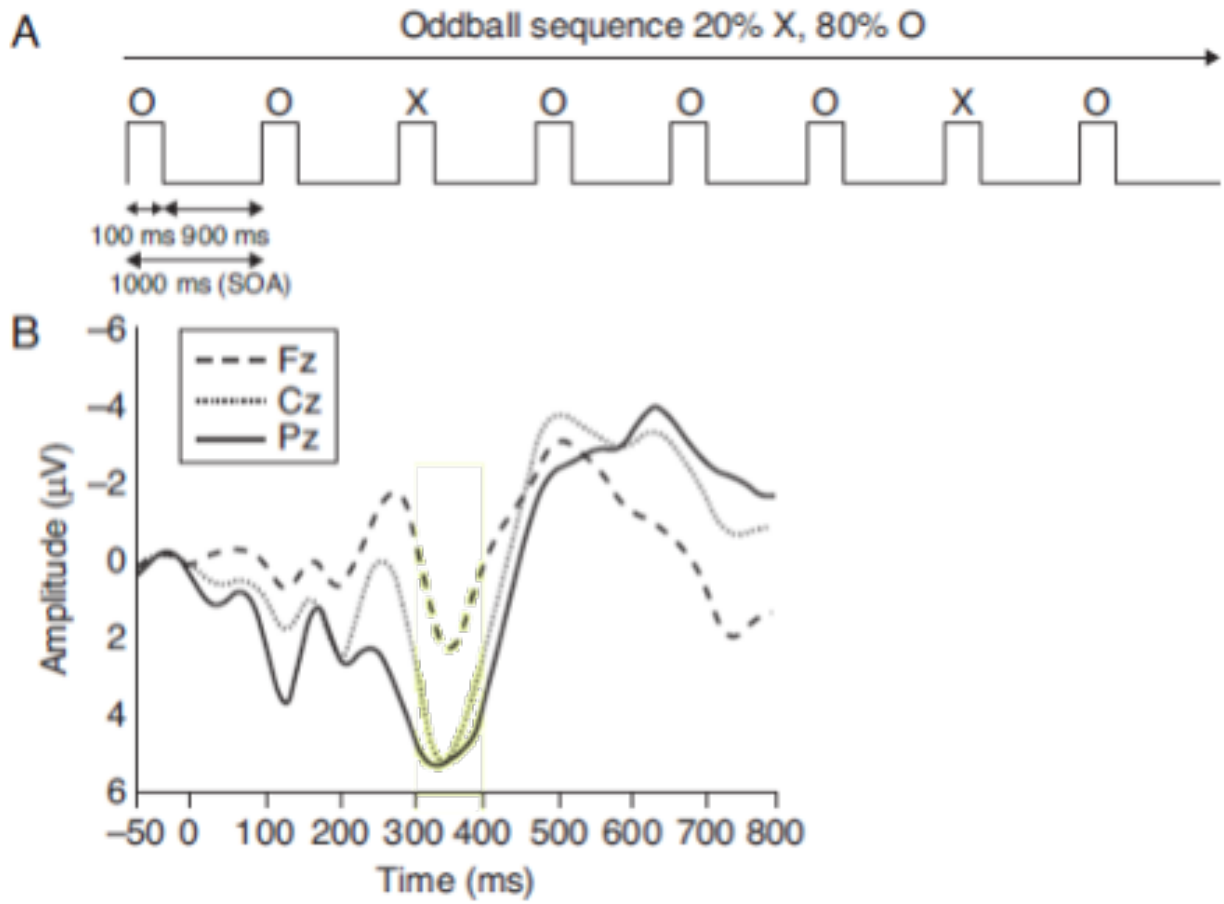

Figure B1. (A) Timeline of the experimental paradigm, showing trials containing 'O' and 'X' stimuli (B) Synchronized averages of 'X' trials.

(End of the test)