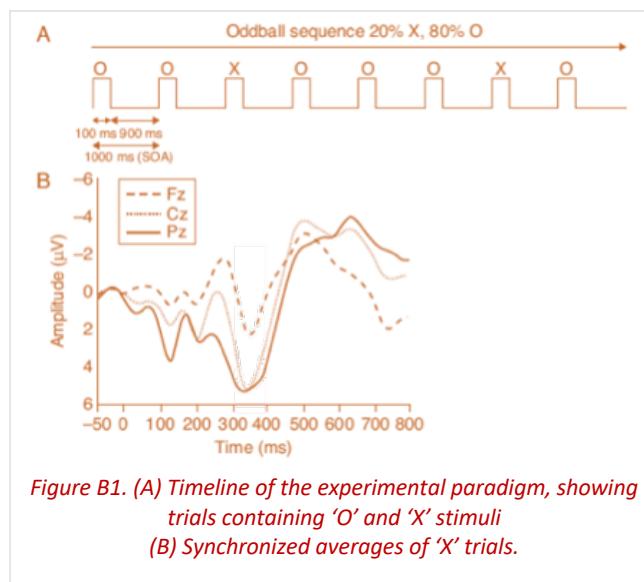## Problem B

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 1(A)*.

Three channels (Fz, Cz, and Pz) of monopolar EEG potentials are recorded, segmented into trials, and selectively averaged. The waveforms in *Figure 1(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 1*.

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

Questions:

Q1. Would a high-pass filter with cutoff frequency at 30 Hz significantly affect the amplitude of the ERPs shown in *Figure 1(B)*? Justify in max 2 lines.

Answer 1
Answer: Yes
Justification:
All components of the ERP have a frequency lower than 30 Hz (or equivalently, a period longer than $1/30 Hz = 33.3\ ms$) and thus are attenuated by the filter.

Q2. Determine the approximate latency of the P300 component on a frontal channel.
Describe the measurement process in max 2 lines.

Answer 2
Latency: ~350 ms
Explanation:

It is the latency of the lowest point of the dashed line (Fz, a frontal channel).
(See also the vertical marker in the figure below.)

Q3. Determine the approximate amplitude of the P300 component on each channel. State whether the ERP more positive on the anterior or posterior part of the scalp.

Answer 3
Amplitudes: Fz= +2 µV; Cz= +5 µV; Pz=+5 µV
Statement: The amplitude is more positive on the posterior part of the scalp.
(See also the horizontal markers in the figure below. Note that the amplitude axis is positive-down.)

Q4. 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 in max 5 lines.

Answer 4
Duration: 8 minutes and 20 seconds
Justification:
We need $K^2 = 100$ trials with 'X' stimulus, thus $K^2/P = 500$ total trials. The total duration is $SOA \cdot K^2/P = 500\ s = 8'20"$ (The SOA must be used rather than the ITI, otherwise the trial duration is underestimated by the 'on' time of the stimulus).

Q5. 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 quadrupling the number of useful trials)?
Justify in max 5 lines.

Answer 5
Answer: No
It is true that having a larger number of trials reduces the denominator of the signal-to-noise ratio. On the other hand, P300 is always elicited by the unpredicted (rare) events. If the proportion of the "rare" stimulus is increased close to or above the chance level (50%), the brain does not respond anymore with a P300 potential, thus the numerator of the signal-to-noise ratio is reduced by an even greater amount.
(Note that since the proportions (20%-80%) are swapped between stimuli, the very same P300 potential might be obtained in this case by averaging the 'O' stimuli.)

A Oddball sequence 20% X, 80% O

O   O   X   O   O   O   X   O

100 ms 900 ms
1000 ms (SOA)

B

- - - Fz
······ Cz
——— Pz

Amplitude (μV)

−6 −4 −2 0 2 4 6

Time (ms)
−50 0 100 200 300 400 500 600 700 800