Neuroengineering 2019-2020

Exam 7 July 2020 – Part I

Solutions

Section A

1. Na^+, K^+, Cl^-, Ca^{++}.
2. False. The amplitude and duration of an action potential are always the same (all-of-none process). The information is not in its shape, but in the temporal distance between two spikes.
3. B (The occipital lobe).
4. False. It is proportional to how richly innervated that body region is, i.e. to the complexity and number of motor connections (e.g., the hand region is larger than the trunk region).
5. Cortical sources produce stronger, more focused scalp EEG signals because they are closer to the electrodes and generate an open field, due to the pyramidal neurons. Deep sources produce attenuated, blurred scalp EEG signals because they are more distant from the electrodes and they often generate a closed field, due to their shape and neuronal orientation.
6. A- False (any stimulus closer than the fixation point will produce zero spikes) B- True
   C- True
   D- True
7. When *isi* is very low, data do not align with the exponential rule. The reason is that the (uncorrected) Poisson generator does not simulate the absolute and relative refractory periods, which make it impossible or less probable, respectively, to have a spike at a very short distance from the previous one.
8. True.
9. True.
10. A. True
    B. False. PDC is a directed estimator, so $PDC_{i\rightarrow j}$ can be different from $PDC_{j\rightarrow i}$
    C. True. PDC is a spectral estimator.
    D. False. If a source is not included in the multivariate modelling, the problem of the hidden source can still occur and lead to spurious results.
11. E_g regular < $\mathbf{E_g}$ **real** < E_g random
    E_I random << $\mathbf{E_I}$ **real**< E_I regular

Section B

	Question	Ans.	Explanation
1	The frequency of oscillation of the beta rhythm is around 10 Hz	F	The minimum conventional oscillation frequency of the beta rhythm is 14 Hz
2	The oscillations of mu rhythm are more “arc-shaped”, rather than resembling a regular sinewave	T	
3	The advantage of a high CMRR amplifier is that it suppresses common-mode disturbances such as powerline (50 Hz) noise.	T	
4	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.	T	
5	Contact impedance of the electrodes can be measured using a direct (non-alternating) current.	F	Contact impedance is frequency dependent and must be measured with an alternating current in the same frequency range as the EEG.
6	The EEG electrode F8 is located to the left of electrode F7	F	In the International 10-20 System, labels with odd/even numbers are located over the left/right hemisphere
7	An eyeblink produces an artifact which often interferes with the analysis of the beta band of the EEG.	F	An eyeblink artifact is a slow wave lasting several tens of a second (i.e. well below 10 Hz)
8	Powerline noise is accentuated by asymmetries in the recording electrode pairs, such as impedances and cable path, because asymmetries prevent the noise to be rejected by the amplifier’s common-mode rejection capabilities.	T	
9	Notch filters effectively remove powerline noise because they selectively reject the narrow band affected by the artifact, preserving almost entirely the useful signal.	T	
10	The potential at the peak of the EP component P20 is higher than the potential at the peak of the N100 component	T	

11	One can never remove one of the channels from the raw EEG recording prior to analysis. Rather all epochs contaminated from artifacts will be rejected.	F	Artifact rejection should aim at minimizing the amount of data discarded. If removing a whole channels prevents discarding a large number of trials, this option should be considered.
12	Evoked brain activity is phase-locked to the stimulus to which it is a response.	T	
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.	T	
14	In Analog to Digital Conversion, the Nyquist frequency equals half of the sampling frequency.	T	
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.	T	
16	Quantization divides the input range of the ADC into (approximately) $NBITS$ intervals, where NBITS is the number of bits of the ADC.	F	Quantization divides the input range of the ADC into (approximately) 2^{NBITS} intervals
17	The RMS and the standard deviation of a zero-mean signal have the same value (assume that the number of samples $N \to \infty$).	T ([1])	
18	The frequency spectrum of white noise is flat, i.e. it has the same power at any frequency.	T	
19	The Central Limit Theorem (CLT) states that the average of N independent identically distributed signals tends to zero for $N \to \infty$.	F	This is only true if the mean of the signals is zero itself
20	The method of the averaged periodogram to estimate the spectrum of a stochastic signal is applied when a lower variability of the PSD estimate at each frequency sample is desirable, while the spectral resolution Δf is higher than required.	T	
21	The Butterworth filter is a design method in the family of FIR	F	The Butterworth filter is an Infinite Impulse Response (IIR) filter

[1] Doe to a typo in the slides, this question was scored as correct, independently of the answer given.

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.	T	