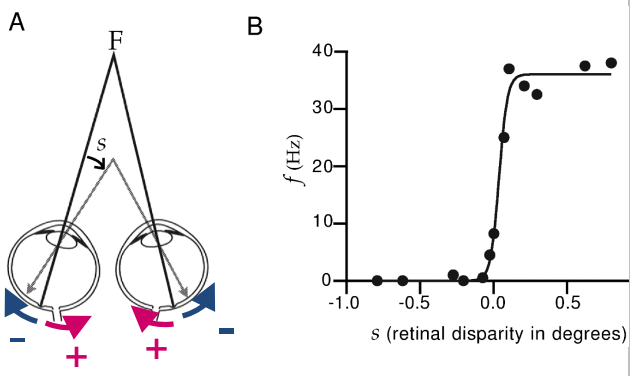
Neuroengineering 2023-2024

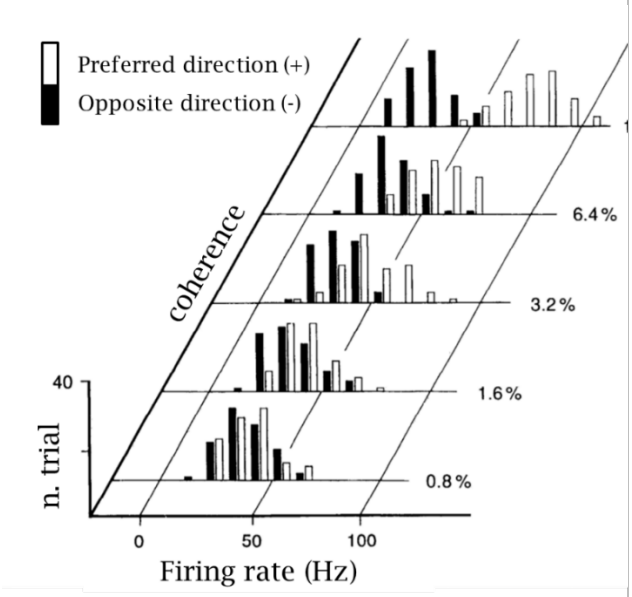
Exam 4 June 2024 – Part I (even)

Solutions

Section A

#	Question	Ans.	Explanation
1	Ion pumps are based on a passive membrane transportation mechanism.	F	*They require an energy expenditure by the cell, therefore they are based on an active mechanism.*
2	Given that at a certain temperature *T* the Cl^- equilibrium potential is equal to -80 mV, and the membrane potential is equal to -70 mV, the Cl^- net current will be directed from the inside of the cell toward the outside.	F	*If the ion equilibrium potential is more negative than the membrane potential, the ion net current will be a hyperpolarizing one. Since Cl^- is a negative ion family, its net hyperpolarizing current will be directed from the outside of the cell toward the inside.*
3	In chemical synapses, when a neurotransmitter opens the K^+ gated channels, the resulting PSP is an inhibitory one.	T	*K^+ gated channels allow the flow of a hyperpolarizing ion current, which in turn produces an inhibitory PSP.*
4	The continuous conduction is faster than the saltatory (myelinated) one	F	*The myelinated conduction is faster than the continuous one.*
5	Two ipsilateral regions belong to the same hemisphere.	T	
6	The unmasking of latent synaptic connections is part of the mechanisms behind brain plasticity.	T	
7	To detect a sequence of action potentials over the axon of a neural cell *in vivo*, the correct procedure is to record extracellular measures.	T	
8	The cortical pyramidal neurons are oriented tangentially to the cortical surface.	F	*They are oriented normally to the cortical surface.*
9	Synchronously activated neurons produce a larger EEG signal than the same amount of neurons when they are asynchronous.	T	

#	Question	Ans.	Explanation
10	Deep (subcortical) regions of the brain produce a less blurred scalp EEG than cortical ones.	F	*Due to their position and their distance from the electrodes, and because of volume conduction effects, subcortical sources produce a more blurred scalp EEG than cortical ones.*
11	Given the following tuning curve, showing the firing rate *f* of a neuron in the primary visual cortex (panel B) as a function of the retinal disparity angle *s* (panel A):  From the figure, we can infer that the neuron responds mainly to negative *s* (closed-tuned neuron).	F	*From the figure, the neuron responds mainly to positive disparity angles (far stimuli).*
12	In reference to the previous figure: from the curve, if the neuron firing rate is equal to 0 Hz I can exactly infer which retinal disparity produced that response.	F	*The retinal disparity in degrees cannot be inferred when the firing rate is equal to 0, because there is a large range of (negative) values that would produce the same response.*
13	In reference to the previous figure: there are retinal disparity angles to which this neuron is "blind" (i.e., it doesn't show any response).	T	

#	Question	Ans.	Explanation
14	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 between the dots:  Discriminability *d'* is higher when the coherence level is equal to 6.4% than when it is equal to 12.8%.	F	*Discriminability is higher when the two distributions are less overlapped, i.e. when the coherence level is equal to 12.8% rather than to 6.4%.*
15	In reference to the previous figure: the histogram obtained for the preferred direction (+) is less affected by the coherence level than the distribution (-).	F	*On the contrary, it is the one affected by the coherence level.*
16	In reference to the previous figure: there is an optimal value *z* that can be used as a threshold for classification at all coherence levels	F	*The optimal value of the threshold z depends on the two distributions, therefore it is different for different coherence levels.*
17	If a time series is not Fourier-transformable, it is impossible to compute its PSD.	F	*The PSD can be computed by means of the Wiener-Khinchin Theorem even if the time series is not Fourier-transformable.*
18	A necessary condition for a linear autoregressive (AR) model is that the time series to be modeled is wide-sense stationary.	T	

#	Question	Ans.	Explanation
19	PDC is a spectral, bivariate method.	F	*It is a spectral, multivariate method.*
20	The use of Ordinary Coherence can mitigate the problem of the common source.	F	Being a pairwise method, the Ordinary Coherence cannot mitigate nor solve the problem of the common source.
21	A negative value of the Granger Index $G_{x\to y}$ should never occur if the two AR models that are compared to compute the index are correct.	T	
22	In a graph, the distance *d(i,j)* between two nodes is given by the average length of the paths that link them.	F	*It corresponds to the shortest (oriented) path between the nodes.*
23	In a graph, the Global Efficiency $\in[0, 1]$.	T	
24	In an undirected graph, I cannot compute the indegree and the outdegree.	T	*The concept of "in-degree" and "out-degree" is based on directionality.*

Section B

#	Question	Ans.	Explanation
1	It is more likely that samples of zero mean a gaussian noise will have amplitude in the range [-0.5,+0.5] rather than in [0.5,1.5]	T	*The Gaussian probability distribution peaks at 0, thus probability is higher in an interval centered in 0 (when both intervals have the same width).*
2	The amplitude of a P300 event related potential be voluntarily modulated through the exercise of motor imagery, to build a cursor control based on a BCI.	F	*Through motor imagery an individual can learn to modulate sensorimotor rhythms, not ERPs*
3	Induced activity is often examined by analyzing the envelope of the EEG in a relevant frequency band, i.e. by rectifying or squaring the pass-band filtered trials before averaging them.	T	*TRUE*
4	The CMRR of a bipolar amplifier measures the ratio between the gain of their average with respect to the electrical ground and the gain of the potential difference between the input electrodes.	F	*Numerator and denominator are swapped*
5	The proper (visual) alpha rhythm is modulated (synchronized, desynchronized) by opening and closing the eyes. This phenomenon is best observed on the frontal EEG channels.	F	*Only the first half of the statement is true. The primary visual area is located in the occipital cortex, thus the occipital (and parietal) channels are most sensitive.*
6	Aliasing occurs when an analog signal is sampled using a limited input range of the ADC.	F	*Aliasing occurs when an analog signal is sampled outside the conditions set by the Shannon's theorem. Clipping (saturation) occurs when the input range of the ADC is smaller than the amplitude of the input analog signal.*
7	$ARV_x = \sqrt{\frac{1}{N}\sum_i (x[i])^2}$, where the sum extends on the N samples of the signal x[i]	F	$ARV_X = \frac{1}{N}\sum_i \lvert x_i \rvert$, *ARV being the acronym of Average Rectified Value*
8	In ERP analysis, the EEG continuous recording must be segmented into epochs (trials) of fixed duration, each aligned to a repetition of the event	T	*TRUE*
9	In an ERP, the response to a stimulus has a reduced amplitude when the SOA is too short.	T	*TRUE*

#	Question	Ans.	Explanation
10	The Central Limit Theorem (CLT) states that the average of N zero-mean independent identically distributed signals approaches zero for $N \to \infty$.	T	*TRUE*
11	The artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings	F	*EOG artifacts can be two orders of magnitude higher than that.*
12	If the electrodes' contact impedance is not much lower than the amplifier's input impedance, the amplitude of the measured potential is closer to zero than the actual value.	T	*True. In fact, the series of the electrode impedance and input impedance act as a voltage divider. Only if the former is much lower than the latter, the voltage at the amplifier's input is approximately equal to the actual biological potential.*
13	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.	F	*IIR filters cannot be designed to have liner phase*
14	A negative peak in a ERP recorded on a specific subject with a latency of $108ms$ may still be named N100, if it matches the physiological phenomenon of the nominal N100 component.	T	*TRUE*
15	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$	T	*TRUE*
16	EEG electrodes whose first letter of the label is "C" (e.g. "Cz") are located on the central region of the head, i.e. the region between the left and the right hemisphere	F	*The central region is above the central sulcus which divides the frontal and parietal lobes. The mesial region is above the interhemispheric scissure, and it is designated by a trailing "z" in EEG labels*
17	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.	T	*TRUE*
18	The frequency response of a filter in the stopband should be plotted in a graph whose vertical axis has a logarithmic scale (i.e. the gain is expressed in dB).	T	*TRUE*

#	Question	Ans.	Explanation
19	Evoked potential is synonymous of Event-Related Potentials	F	*Event related potentials include evoke potentials, as well as EEG responses to motor or cognitive events.*
20	The DFT of a signal represents the amplitude A_i and initial phases ϕ_i of sinewave components of the signal at frequencies f_i ranging from $0Hz$ (included) to the sampling frequency (excluded).	T	*TRUE*
21	The alpha rhythm can be observed by filtering the spontaneous EEG signal using a narrowband filter, with cutoff frequencies at 14 and 30 Hz (approximately)	F	*With these cutoff frequency we would observe the beta rhythm*
22	The measurement of two monopolar EEG channels requires four electrodes – two collecting the potentials fed to the non-inverting input of the differential amplifier, one providing the reference potential and one providing the ground potential.	T	*TRUE*
23	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of $sinc(\cdot)$ functions, one for each sample.	T	*TRUE*
24	Despite being more expensive, gold electrodes should be preferred to Ag/AgCl electrodes since they allow recording of extremely slow-changing EEG potentials.	F	*Gold electrodes are polarizable, thus the opposite is true*