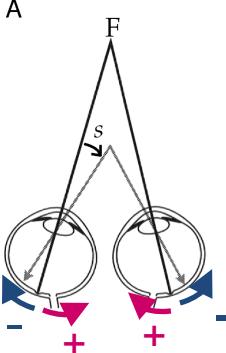
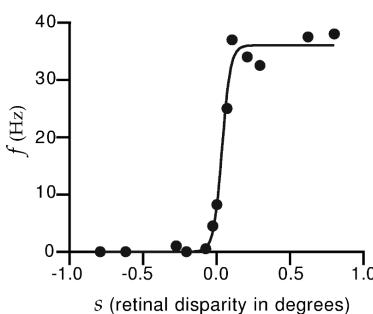


Neuroengineering 2023-2024
Exam 19 October 2024 – Part I

Solutions

Section A

#	Question	Ans.	Explanation
1	Ion pumps are based on a passive membrane transportation mechanism.	F	<i>They require an energy expenditure by the cell, therefore they are based on an active mechanism.</i>
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	<i>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.</i>
3	In chemical synapses, when a neurotransmitter opens the K^+ gated channels, the resulting PSP is an inhibitory one.	T	<i>K^+ gated channels allow the flow of a hyperpolarizing ion current, which in turn produces an inhibitory PSP.</i>
4	The continuous conduction is faster than the saltatory (myelinated) one	F	<i>The myelinated conduction is faster than the continuous one.</i>
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 <i>in vivo</i> , the correct procedure is to record extracellular measures.	T	
8	The cortical pyramidal neurons are oriented tangentially to the cortical surface.	F	<i>They are oriented normally to the cortical surface.</i>
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	<i>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.</i>
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): A  B  From the figure, we can infer that the neuron responds mainly to negative s (closed-tuned neuron).	F	<i>From the figure, the neuron responds mainly to positive disparity angles (far stimuli).</i>
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	<i>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.</i>
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:	F	<i>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%.</i>
	<p>Discriminability d' is higher when the coherence level is equal to 6.4% than when it is equal to 12.8%.</p>		
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	<i>On the contrary, it is the one affected by the coherence level.</i>
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	<i>The optimal value of the threshold z depends on the two distributions, therefore it is different for different coherence levels.</i>
17	If a time series is not Fourier-transformable, it is impossible to compute its PSD.	F	<i>The PSD can be computed by means of the Wiener-Khinchin Theorem even if the time series is not Fourier-transformable.</i>
18	A necessary condition for a linear autoregressive (AR) model is that the time series to be modeled is wide-sense stationary.	T	
19	PDC is a spectral, bivariate method.	F	<i>It is a spectral, multivariate method.</i>

#	Question	Ans.	Explanation
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 $G_{x \rightarrow y}$ 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	<i>It corresponds to the shortest (oriented) path between the nodes.</i>
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	<i>The concept of "in-degree" and "out-degree" is based on directionality.</i>

Section B

#	Question	Ans.	Explanation
1	The mu rhythm and the alpha rhythm are EEG components that differ for their fundamental frequency of oscillation	F	They both oscillate around 10 Hz.
2	The “waxing and waning” of the alpha rhythm is a change of amplitude whose duration is in the order of magnitude of 1 second.	T	True. Not to be confused with the oscillations of the alpha rhythm, which occur an order of magnitude faster.
3	Event-Related Desynchronization/ Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.	F	ERD/S quantify changes of the power of EEG relative to a baseline period
4	The CMRR of an EEG amplifier should be higher than 90 dB	T	TRUE
5	The contact impedances of a pair of electrodes should be large compared to the input impedance of the differential amplifier connected to them, otherwise the amplitude of the signal would be reduced as effect of the potential divider.	F	False, the contact impedances must be <i>lower</i> than the amplifier's input impedance, mainly to help keeping the circuit balanced (higher CMRR)
6	An EEG recording is said to be bipolar when it comprises exactly two channels	F	In bipolar EEG recordings, each channel is the difference of potential between two (adjacent) electrodes. The number of channels is not relevant
7	EEG signals recorded in monopolar configuration can be re-referenced to the Common Average Reference (CAR), by subtracting from each channel the instantaneous average of all channels. In ideal conditions, this would approximate taking the reference potential at infinity.	T	TRUE
8	A ‘run’ is a portion of recording in an experimental protocol that contains no breaks, i.e. all samples contained therein have been acquired $1/f_s$ seconds after the previous (f_s being the sampling frequency)	T	TRUE
9	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, ...).	T	TRUE

#	Question	Ans.	Explanation
10	Movements of the subject's head produces EEG artifacts mainly in the lowest part of the spectrum.	T	Movement of the subject's head may produce slow artifacts on the EEG recording, whose waveform is closely related to the timecourse of the movement
11	When recording EPs, the spontaneous EEG is to be considered a noise that completely masks the EPs on the recorded waveform.	T	True. With very rare exceptions (mostly in the field of pathology) EPs are one or more orders of magnitude smaller than the spontaneous EEG.
12	In ERP analysis, 'trials' are portions of the continuous EEG recording that start exactly at the time when a sensory stimulus was delivered	F	The start of a trial usually precedes the time of the event, so that a pre-stimulus baseline period can be analyzed. Events are not necessarily sensory stimulations.
13	The N20 component of an EP occurs before the stimulus (negative latency) while the P300 occurs after the stimulus (positive latency).	F	'N' and 'P' indicate the sign of the amplitude of the ERP (Negative and Positive, respectively), not the latency.
14	Event-Related Desynchronization/Synchronization (ERD/S) quantify phase-locked brain activity in response to an event	F	Event-Related Desynchronization/Synchronization (ERD/S) quantify relative changes of the power of the EEG rhythm in a predefined frequency range; phase locked activity is estimated using the synchronized averaging.
15	The reconstruction of an analog signal from its sampled version is equivalent to the linear interpolation of the samples.	F F	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of $\text{sinc}(\cdot)$ functions, one for each sample.
16	Aliasing occurs when an artifact corrupts an otherwise healthy EEG recording.	F	Aliasing occurs when the sampling frequency of an analog signal is lower than twice the frequency of any spectral component of the signal
17	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

#	Question	Ans.	Explanation
18	The Average Rectified Value (ARV) is a measure of the amplitude of a signal, and it is obtained by summing the absolute values of all samples and dividing the result by the number of samples.	T	TRUE
19	The variance of a signal is estimated by summing the square of all deviations of the N sample values from the sample mean, and then dividing by $(N - 1)$	T	TRUE
20	The frequency spectrum of white noise is flat, i.e. it has the same power at any frequency.	T	TRUE
21	The Short Time Fourier Transform (STFT) is a simple method to estimate a spectrogram, i.e. the representation of the time-varying spectrum of a non-stationary signal.	T	TRUE
22	The roll-off of a filter is the slope of its frequency response in the transition band. It is high when the transition band is narrow.	T	TRUE
23	A FIR filter needs to be of a higher order to achieve the same quality specifications than a IIR filter.	T	TRUE
24	In a P300-based BCI, the user subjectively assigns saliency (relevance) to a stimulus so that their brain produces a P300 ERP every time the stimulus is administered	T	TRUE