

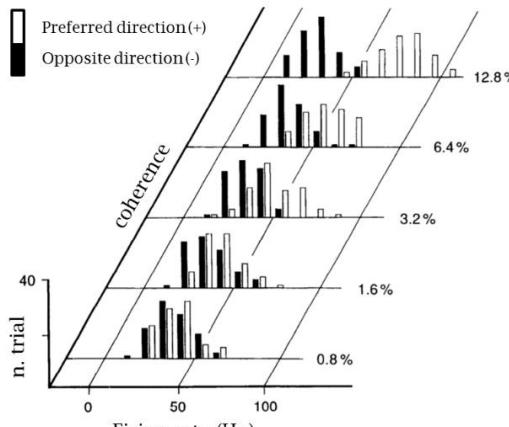
Neuroengineering 2023-2024
Exam 3 February 2025 – Part I

Solutions

Section A

#	Question	Ans.	Explanation
1	An IPSP consists of a depolarization of the post-synaptic cell membrane.	F	<i>Being inhibitory, it consists of a hyperpolarization of the membrane.</i>
2	The inactivation of the voltage-gated Na^+ channel is responsible for the absolute refractory period.	T	
3	The most informative parameter of the spike train in output to a neuronal cell is the amplitude of the spikes.	F	<i>The amplitude of all the spikes is the same, so this is not an informative parameter.</i>
4	The firing rate of the pre-synaptic neuron influences the temporal summation of the PSPs in the post-synaptic cell.	T	
5	The frontal lobe houses the primary visual function.	F	<i>The primary visual cortex is located in the occipital lobe.</i>
6	In the primary motor cortex (Penfield homunculus) the extension of the cortical region which controls a specific body region is proportional to that body region's volume.	F	<i>The extension of the cortical region which controls a specific body region is proportional to the number of motor nerves, not to the body region's volume.</i>
7	To record <i>in vivo</i> measures of the membrane potential over the axon of a single neural cell, you will use extracellular measures.	T	
8	The EEG signal is mainly generated by action potentials.	F	<i>It is mainly generated by post-synaptic potentials.</i>

#	Question	Ans.	Explanation
9	<p>The tuning curve in the figure shows (panel B) the firing rate f of a neuron in the primary visual cortex as a function of the retinal disparity angle s (panel A).</p> <p>A.</p> <p>B</p> <p>From the figure, we can infer that the neuron responds mainly to positive s (far-tuned neuron).</p>	T	
10	In reference to the previous figure: from the curve, if the retinal disparity is equal to -0.5, I can infer which firing rate will be produced by the neuron	T	<i>It will be equal to 0</i>
11	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 a large range of negative values would produce the same response.</i>
12	To record in vitro measures of the membrane potential over the dendrites of a neural cell, you will use extracellular measures	F	<i>Extracellular measures are able to capture only the sequence of APs, not the E/IPSPs that occur over the dendrites. To this purpose, we will use intracellular recordings.</i>
13	The part of the pyramidal neuron that acts as a current dipole is the axon	F	<i>It's the dendritic tree.</i>

#	Question	Ans.	Explanation
14	<p>Given the distribution of firing rates in the figure:</p>  <p>The discriminability d' when the coherence=3.2% is higher than when it's =12.8%</p>	F	<i>The discriminability d' is higher for higher values of the coherence level.</i>
15	<p>In reference to the previous figure (question 14), among the two distributions (r_+ or r_-), r_+ is the one affected by the coherence level</p>	T	
16	The normalized Partial Directed Coherence $\in [0, 1]$	T	
17	The Granger Test is more suitable than the Ordinary Coherence to obtain a spectral measure	F	<i>The Granger Test is not a spectral measure.</i>
18	If $C_{xy}(f)$ is the ordinary coherence between x and y, $C_{xy}(f)=C_{yx}(f)$	T	
19	The difference between the Wiener's and Granger's definitions of causality in the statistical sense is that Granger indicated a modeling framework to be used to test causality	T	
20	Regular networks have a smaller Global Efficiency than random networks	T	
21	Regular networks have a smaller Local Efficiency than random networks	F	<i>They have a larger Local Efficiency.</i>
22	Undirected graphs produce symmetrical adjacency matrices	T	

#	Question	Ans.	Explanation
23	Given the Granger Index G_{xy} between two time series x and y , a negative value of $G_{x \rightarrow y}$ means an inverse precedence between the two time	F	<i>A negative value of G_{xy} means that the residual of the bivariate model is higher than in the simple model, which is probably due to incorrect modeling.</i>
24	Using Partial Directed Coherence completely solves the problem of the hidden (common) source	F	<i>It can mitigate the problem, but if a source is not accessible (e.g. because of limitations of the acquisition method) even PDC cannot remove the resulting spurious connections.</i>

Section B

#	Question	Ans.	Explanation
1	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 frequencies we would observe the beta rhythm
2	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.	T	TRUE
3	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.
4	In an ERP, the response to a stimulus has a reduced amplitude when the SOA is too short.	T	TRUE
5	In an ADC, quantization introduces a noise whose amplitude is proportional to the number L of discrete amplitude levels: $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot L = \frac{1}{\sqrt{12}} \cdot 2^{NBIT}$	F	The quantization noise amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$
6	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.
7	The synchronized average of N trials containing only spontaneous EEG whose variance $\{\text{var}\}\{\text{trial}\} = ^2$ is a signal whose variance $\{\text{var}\}\{\text{avg}\} = ^2/N$	T	TRUE
8	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
9	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

#	Question	Ans.	Explanation
10	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.
11	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
12	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 fissure, and it is designated by a trailing "z" in EEG labels
13	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
14	In analog-to-digital conversion, each spectral component of the analog signal should have frequency below the Nyquist frequency	T	TRUE
15	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
16	The Central Limit Theorem (CLT) states that the average of N zero-mean independent identically distributed signals approaches zero for $N \rightarrow \infty$.	T	TRUE
17	As a preliminary step to EEG data analysis, one or more channels can be removed from the dataset if they are extensively contaminated by artifacts	T	TRUE
18	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.

#	Question	Ans.	Explanation
19	Given two ranges of equal width $A=[-0.1,+0.1]$ and $B=[0.8,1.0]$, it is less likely that samples of a sinewave $x=(t)$ will have amplitude in A rather than B.	T	TRUE, the probability density function of amplitude is lowest for $x = 0$
20	A BCI system may replace functions that are physiologically subserved by nerves and muscles, by directly measuring brain activity and converting it to an artificial output.	T	TRUE
21	The advantage of a high CMRR amplifier is that it suppresses high frequency disturbance.	F	The advantage of a high CMRR amplifier is that it suppresses common-mode disturbances, such as powerline (50 Hz) noise.
22	The purpose a filter is to allow desired spectral component of a signal to pass almost unaltered, while attenuating undesired spectral components	T	TRUE
23	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
24	The Inter-Stimulus Interval (ISI) equals the SOA minus the ITI.	F	The ISI equals the SOA minus the stimulus duration.