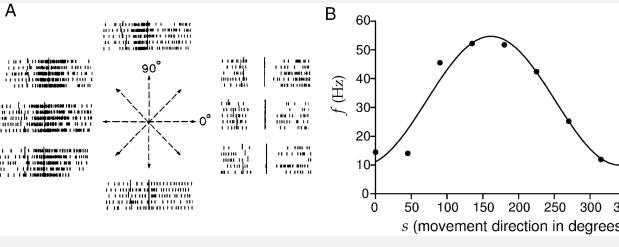
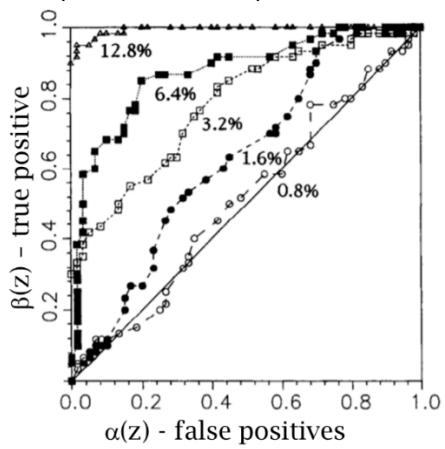


Neuroengineering 2023-2024  
Exam 4 June 2024 – Part I (odd)

Solutions

## Section A

#	Question	Ans.	Explanation
1	In the Nernst equation for the electrochemical equilibrium there is a term referred to diffusional forces and a term referred to electrical forces.	T	
2	Given that at a certain temperature $T$ the $\text{Cl}^-$ -equilibrium potential is equal to $-80$ mV, and the membrane potential is equal to $-70$ mV, the $\text{Cl}^-$ -net current will be a depolarizing one.	F	<i>If the ion equilibrium potential is more negative than the membrane potential, the ion net current will be a hyperpolarizing one.</i>
3	The temporal summation of PSPs does not depend on the temporal distance between subsequent action potentials in the presynaptic cell.	F	<i>The temporal summation occurs when the presynaptic neuron fires multiple times in close succession.</i>
4	A hyperpolarization with respect to the resting membrane potential can cause the generation of an action potential.	F	<i>The generation of an action potential is caused by a depolarization of the neuronal membrane.</i>
5	The motor homunculus is located in the frontal lobe.	T	
6	The short-term synaptic plasticity can involve a structural change in the post-synaptic membrane.	F	<i>Structural changes in the post-synaptic membrane occur with long-term plasticity.</i>
7	To measure the membrane potential over the soma of a neural cell <i>in vitro</i> , the correct procedure is to record extracellular measures.	F	<i>To measure the membrane potential we need intracellular recordings, that can be more easily performed <i>in vitro</i> and on large portions of the cell, like the soma.</i>
8	In a cortical pyramidal neuron, thalamo-cortical synapses are located in the apical portion of its dendritic tree.	F	<i>They are located in the basal part of the dendritic tree.</i>
9	Radially symmetric neurons produce a closed field and therefore do not significantly contribute to scalp EEG.	T	

#	Question	Ans.	Explanation
10	Potentials recorded by electrodes which are at a close distance on the scalp are mutually independent.	F	<i>Due to the volume conduction, there's a strong correlation between scalp potentials recorded at a close spatial distance.</i>
11	Given the following tuning curve, showing the spike trains obtained - for different trials - from a neuron of the primary motor cortex in correspondence to an arm movement (panel A), and the firing rate $f$ of the same neuron as a function of the angle $s$ of the same movement direction (panel B):   <p>The maximum neural response is obtained for a movement direction with an angle of 350 degrees.</p>	F	<i>The maximum neural response is obtained for a movement direction with an angle of 150 degrees.</i>
12	In reference to the previous figure: from the curve, I can conclude that this neuron is tuned to be more active in correspondence to a specific movement direction.	T	
13	In reference to the previous figure (question 10): the firing rate $f$ in panel B was computed as the average of the neural response function across trials.	T	
14	Given the ROC curves in the figure, describing a threshold classification between two conditions (stimuli) at different levels of coherence of the stimulation (different curves):   <p>The best curve is the one closer to the diagonal.</p>	F	<i>The diagonal corresponds to a random binary classification (chance level).</i>

#	Question	Ans.	Explanation
15	In reference to the previous figure: the Area Under the Curve (AUC) for each level of coherence is proportional to the discriminability of the two conditions.	T	
16	In reference to the previous figure: by considering only the true positives and false positives, and neglecting the true negatives and false negatives, we miss part of the results of the classification.	F	<i>True negatives and false negatives are related to false positives and true positives, respectively. Therefore, we are not neglecting any result of the classification.</i>
17	The Spectral Matrix computed for any given pair of time series is always symmetrical.	T	
18	Given two time series $x$ and $y$ , the Granger Causality Index $G_{x \rightarrow y} \in [-\infty, \infty]$ .	F	<i>The Granger Causality Index <math>G_{x \rightarrow y} \in [0, \infty]</math>.</i>
19	When we have a limited amount of data, the Partial Directed Coherence (PDC) is the most accurate estimator of causality in the statistical sense.	F	<i>In the event of data paucity, PDC returns inaccurate results due to the low ratio between data samples and model parameters.</i>
20	The Ordinary Coherence is defined in the time domain.	F	<i>It is defined in the spectral domain.</i>
21	A multivariate approach to the estimation of brain networks can always prevent the occurrence of the common source problem.	F	<i>Since there is no method able to simultaneously measure all the active sources in the brain, the problem of the common (hidden) source can be mitigated, but not entirely solved, by a multivariate approach.</i>
22	In a graph, when no path links two nodes, the distance between them is infinite.	T	
23	In a graph, the Density $\in [0, 1]$ .	T	
24	The Global Efficiency is normalized to the number $N$ of nodes in the graph.	F	<i>The Global Efficiency is normalized to the number of edges <math>N(N-1)</math> for directed graphs and <math>N(N-1)/2</math> for undirected graphs.</i>

# Section B

#	Question	Ans.	Explanation
1	Aliasing occurs when an analog signal is sampled using a limited input range of the ADC.	F	<i>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.</i>
2	The heart activity is likely to contaminate an EEG recording if the reference electrode is not placed on the head.	T	<i>TRUE</i>
3	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	<i>TRUE</i>
4	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	<i>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</i>
5	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	<i>The Gaussian probability distribution peaks at 0, thus probability is higher in an interval centered in 0 (when both intervals have the same width).</i>
6	The DFT of a signal represents the amplitude $A_i$ and initial phases $\phi_i$ of sinewave components of the signal at frequencies $f_i$ ranging from 0Hz (included) to the sampling frequency (excluded).	T	<i>TRUE</i>
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	<i><math>ARV_X = \frac{1}{N} \sum_i  x_i </math>, ARV being the acronym of Average Rectified Value</i>
8	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	<i>TRUE</i>
9	In an ERP, the response to a stimulus has a reduced amplitude when the SOA is too short.	T	<i>TRUE</i>

#	Question	Ans.	Explanation
10	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	<i>TRUE</i>
11	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	<i>IIR filters cannot be designed to have liner phase</i>
12	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	<i>Numerator and denominator are swapped</i>
13	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.	T	<i>TRUE</i>
14	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	<i>TRUE</i>
15	Despite being more expensive, gold electrodes should be preferred to Ag/AgCl electrodes since they allow recording of extremely slow-changing EEG potentials.	F	<i>Gold electrodes are polarizable, thus the opposite is true</i>
16	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	<i>Through motor imagery an individual can learn to modulate sensorimotor rhythms, not ERPs</i>
17	The Central Limit Theorem (CLT) states that the average of $N$ zero-mean independent identically distributed signals approaches zero for $N \rightarrow \infty$ .	T	<i>TRUE</i>
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	<i>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.</i>
19	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	<i>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.</i>

#	Question	Ans.	Explanation
20	The artifact generated by eye movements can reach amplitudes up to $5\mu V$ in the EEG recordings	F	<i>EOG artifacts can be two orders of magnitude higher than that.</i>
21	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	<i>TRUE</i>
22	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	<i>With these cutoff frequencies we would observe the beta rhythm</i>
23	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	<i>TRUE</i>
24	Evoked potential is synonymous of Event-Related Potentials	F	<i>Event related potentials include evoke potentials, as well as EEG responses to motor or cognitive events.</i>