

Neuroengineering 2021-2022

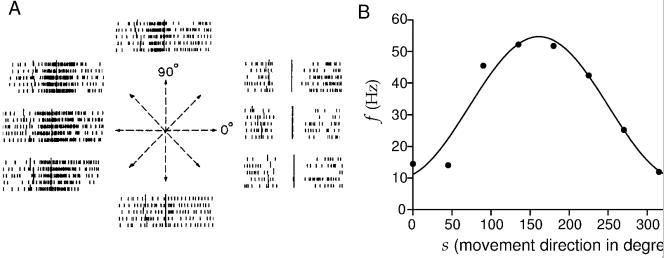
Exam 21 July 2022 – Part I

Solutions - Odd seats

Section A

	Question	Ans.	Explanation
1	In a Poisson spike generator, the program generates a fixed threshold and, at each time step, compares the variable $rest\Delta t$ with the fixed threshold.	F	<i>The threshold is randomly variable, while $rest\Delta t$ is a constant for a given value of s.</i>
2	If $C_{xy}(f)$ is the Ordinary Coherence between x and y , $C_{xy}(f)=C_{yx}(f)$.	T	
3	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 series.	F	<i>A negative value of $G_{x \rightarrow y}$ means that the residual of the bivariate model is higher than in the simple model, which is probably due to an incorrect modeling.</i>
4	In the event of data paucity, the Partial Directed Coherence (PDC) is the most accurate estimator of causality in the statistical sense.	F	<i>When we have a limited amount of data, PDC returns inaccurate results due to the low ratio between data samples and model parameters.</i>
5	In an undirected graph, I cannot compute the indegree and the outdegree.	T	<i>In an undirected graph, the concept of "in-degree" and "out-degree" is meaningless.</i>
6	Random networks have a smaller Local Efficiency than regular (lattice) networks.	T	
7	In a graph, the minimum Divisibility is equal to zero.	F	<i>The minimum Divisibility is equal to 0.5</i>
8	Divisibility and Modularity are measures of segregation of a network.	T	
9	The brain operates at the temporal scale of milliseconds.	T	
10	The synchronicity of the neural activity affects the amplitude of EEG signals.	T	
11	Scalp EEG is mainly produced by deep (subcortical) regions.	F	<i>It is mainly produced by cortical regions.</i>
12	The electrical variation of the membrane potential that mainly contributes to EEG is the action potential.	F	<i>The synchronous variations of post-synaptic potentials (and their extracellular effects) are the main contributors to EEG signals.</i>

13.	<p>Given the ROC curves in the figure, describing a threshold classification between two conditions (stimuli) at different levels of coherence of the stimulation:</p> <p>The best curve is the one closer to the upper left corner.</p>	T	
14	In reference to the previous figure (question 13): the Area Under the Curve (AUC) for each level of coherence is proportional to the discriminability of the two conditions.	T	
15	The long-term synaptic plasticity involves a structural change in the post-synaptic membrane.	T	
16	The voltage-gated K ⁺ channel inactivation state is responsible for the absolute refractory period.	F	<i>The voltage-gated Na⁺ inactivation state is responsible for the absolute refractory period. K⁺ voltage-gated channel does not go through any inactivation state.</i>
17	The voltage-gated Na ⁺ channel is responsible for the repolarization phase of the action potential.	F	<i>The repolarization phase of the action potential is due to the opening of the voltage-gated K⁺ channel.</i>
18	Temporal and spatial summation can occur simultaneously.	T	
19	The firing rate influences the amplitude of the resulting action potential in the post-synaptic cell.	F	<i>It can affect the temporal summation and therefore the amplitude of the post-synaptic potentials, not of the action potential.</i>

20	<p>The tuning curve in the figure shows (panel A) the spike trains obtained - for different trials - from a neuron of the primary motor cortex in correspondence to an arm movement, and (panel B) the firing rate f of the same neuron as a function of the angle s of the same movement direction:</p>  <table border="1"> <caption>Data points estimated from Panel B graph</caption> <thead> <tr> <th>movement direction s (degree)</th> <th>firing rate f (Hz)</th> </tr> </thead> <tbody> <tr><td>0</td><td>15</td></tr> <tr><td>50</td><td>18</td></tr> <tr><td>100</td><td>45</td></tr> <tr><td>150</td><td>55</td></tr> <tr><td>175</td><td>55</td></tr> <tr><td>200</td><td>52</td></tr> <tr><td>250</td><td>38</td></tr> <tr><td>300</td><td>15</td></tr> </tbody> </table> <p>When the firing rate is 55 Hz, I can infer which movement direction produced that response.</p>	movement direction s (degree)	firing rate f (Hz)	0	15	50	18	100	45	150	55	175	55	200	52	250	38	300	15	T	<p><i>Yes, because there's a unique value of s that can produce a neuronal response with that firing rate.</i></p>
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21	<p>In reference to the previous figure (question 20): from the curve I can conclude that this neuron is tuned to be active in correspondence to a given movement direction.</p>	T																			
22	<p>In reference to the previous figure (question 20): the firing rate f in panel B was computed as the average of the neural response function across trials.</p>	T																			

Section B

	Question	Pts.	Ans.	Explanation
1	The amplitude of the mu rhythm is increased at the beginning of a motor task	0.5	F	The mu rhythm desynchronizes (i.e. its amplitude decreases) during the planning and execution of a motor task
2	Evoked Potentials are deflection of the EEG signal following the presentation of a sensory input.	0.5	T	True
3	Ag/AgCl electrodes allow recording of extremely slow-changing EEG potentials.	0.5	T	True
4	The advantage of a high CMRR amplifier is that it suppresses common-mode disturbances such as powerline (50 Hz) noise.	0.5	T	True
5	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.	0.5	T	True
6	The position of the reference electrode can strongly influence the shape and amplitude of EEG potentials. The profile (i.e. disregarding the actual potential value) of scalp topographies are not influenced.	0.5	T	True
7	Digital processing can remove all significant artifacts, and thus it is not worth using the measurement time to reduce their presence on the raw recording.	0.5	F	Digital processing can only reduce artifacts, and may introduce distortions in the useful signal. Whenever possible/convenient artifacts should be avoided at recording time.
8	Powerline noise is an artifact caused by the capacitive coupling between the power supply conductors and the recording setup including the subject.	0.5	T	True
9	Movements of the subject's head produces artifacts only in the gamma band.	0.5	F	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
10	The potential at the peak of the EP component P20 is lower than the potential at the peak of the N100 component	0.5	F	P20 is a positive peak, N100 is a negative peak. The potential of the former is thus higher.
11	The Inter-Stimulus Interval (ISI) measures the time interval between the end of a stimulus and the beginning of the following one.	0.5	T	True

	Question	Pts.	Ans.	Explanation
12	Brain activity in response to a stimulus can be non-phase-locked, meaning that they show variable latency (jitter) at each repetition. This activity is called <i>induced</i> .	0.5	T	True
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.	0.5	T	True
14	The reconstruction of an analog signal from its sampled version is equivalent to the sum a set of a set of <i>sinc()</i> functions, one for each sample.	0.5	T	True
15	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval: $\sigma_{quant} = 1/\sqrt{12} \text{ LSB}$	0.5	T	True
16	Appropriate application of a high-pass digital filter may prevent saturation by removing high amplitude slow artifacts.	0.5	F	False, saturation can be prevented only by applying an analog filter before A/D conversion
17	The sample variance of a signal is given by $s_X^2 = \frac{1}{N-1} \sum_{i=1}^N (x_i - \bar{X})^2$, where the sum extends on the N samples of the signal X	0.5	T	True
18	In a gaussian noise, the probability density that a sample has a given amplitude value follows the normal distribution with zero mean.	0.5	T	A gaussian noise has normal distribution of amplitude of the samples. [A white noise has a flat spectrum.]
19	Given 100 independent and identically distributed random variables with variance equal to 4, the variance of their average is 0.04?	0.5	T	$\sigma_{avg}^2 = \sigma^2/N$
20	The spectral leakage phenomenon is observed, for instance, when comparing the spectrum of a signal with the spectrum of a short section of the same signal.	0.5	T	True
21	The output of FIR filters is the linear combination of samples of the input. The output of IIR filters combines both samples of the input and past samples of the output.	0.5	T	True
22	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	0.5		True
	Total points	11		