

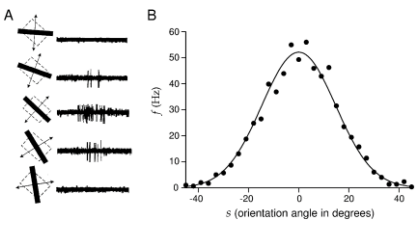
Neuroengineering 2019-2020

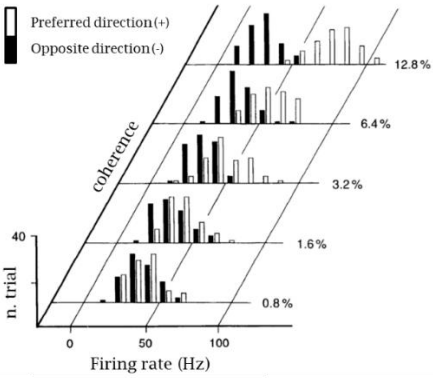
Exam 9 June 2020 – Part I

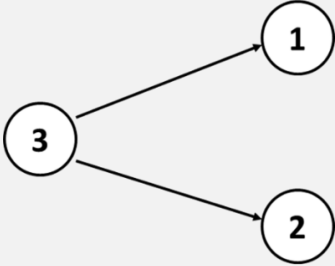
Solutions

Section A

	Question	Answer	Points (correct)	Points (wrong)
1	The voltage-gated Na ⁺ channel inactivation state is responsible for the absolute refractory period.	T	0.5	-0.25
2	The voltage-gated K ⁺ channel is responsible for the repolarization phase of the action potential.	T	0.5	-0.25
3	Given a spike train in output to a neuronal cell, what will the frequency of the spikes influence? A. The spatial summation of the PSPs B. The amplitude of the action potential produced by the post-synaptic cell C. The temporal summation of the PSPs	C	1	-0.33
4	The short-term synaptic plasticity involves: A. A structural change in the post-synaptic membrane B. An increased number of membrane receptors C. The amount of neurotransmitter released in the synaptic cleft D. An irreversible change in the synaptic structure	C	1	-0.25
5	Indicate which part of the brain tissue contributes more to the EEG signal: A. The cortical sulci B. The cortical gyri C. The subcortical regions D. The cerebellum	B	1	-0.25

6	<p>Given the following tuning curve:</p>  <p>A. If the measured firing rate is 20 Hz, can I infer which was the orientation angle that produced that response? Why?</p> <p>B. Is there a preferred stimulus orientation for which this neuron is designed to respond? How can I tell?</p> <p>Type a brief answer, max 2 lines for each question.</p>	<p>6.A. No, because this firing rate can result from two different values of s (-20° and 20°) <i>(note: you need to look for the values of s that produce an $f=20$ Hz)</i> <i>(N.B. The answers that explained the above were took as correct, even if they said "Yes")</i></p> <p>6.B. Yes. I can conclude that because the tuning curve has a (single) maximum <i>(note: the preferred stimulus orientation is the value of s corresponding to the curve peak)</i></p>	2	0
7	<p>In a Poisson spike generator:</p> <p>A. the program generates, at each time step, a random threshold, independent from r, and then compares the fixed r with the variable threshold</p> <p>B. the program generates a fixed threshold and, at each time step, compares the variable r with the fixed threshold</p> <p>C. the program generates, at each time step, a variable threshold dependent from r and then compares the variable r with the variable threshold</p>	<p>A <i>(note: the threshold is random and independent from r. Higher values of r will have higher probability of being above the threshold)</i></p>	1	-0.33

8	<p>Given the distribution of firing rates in the figure, indicate, for each of the following sentences, if they are true or false:</p>  <p>A. The discriminability d' when the coherence =12.8% is higher than when it's =3.2%</p> <p>B. Higher coherence levels require lower values of the classification threshold z</p>	<p>8.A: T 8.B: F</p>	<p>0.5 0.5</p>	<p>-0.25 -0.25</p>
9	<p>Explain the difference between anatomical and functional connectivity</p>	<p>Anatomical connectivity is the set of physical or structural connections linking sets of neurons or brain regions. It is constant for time scales ranging up to hours and days. Functional connectivity represents the existence of correlation or causation between the activity in different neuronal groups or regions. It is highly variable in time (milliseconds).</p>	<p>1</p>	<p>0</p>
10.	<p>Given the Granger test between two time series x and y, indicate, for each of the following sentences, if they are true or false:</p> <p>A. $G_{x \rightarrow y}$ is always equal to $G_{y \rightarrow x}$</p> <p>B. $G_{x \rightarrow y} \in [0, 1]$</p>	<p>10.A: F 10.B: F</p>	<p>0.5 0.5</p>	<p>-0.25 -0.25</p>

11	<p>Given the following network, and assuming we can measure all the three signals and we have enough data, which approach is recommended to avoid spurious links?</p>  <pre> graph LR 3((3)) --> 1((1)) 3((3)) --> 2((2)) </pre> <p>Type a brief answer, max 1 line.</p>	A multivariate approach (e.g., PDC) is recommended to avoid the hidden source problem.	1	0
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Section B

	Question	Ans.	Explanation
1	The beta band identify frequencies lower than the alpha band	F	The conventional frequency band of the beta band starts at 14 Hz, above the alpha band
2	The CMRR is usually expressed in decibel (dB) and high values characterizes better amplifiers.	T	
3	Ensuring a contact impedance below $5\text{ k}\Omega$ is not relevant when the input impedance of the EEG amplifier is below $50\text{ k}\Omega$	F	Contact impedances of the electrodes must be much lower than the input impedance of the amplifier.
4	An artifact is a potential difference due to sources outside the brain.	T	
5	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.	F	Artifacts must be prevented during acquisition in the first place. Only when technically unfeasible or too time consuming, off-line signal conditioning can <i>attenuate</i> them.
6	A sudden movement of the eyes to the left generates a negative deflection of EEG potentials on the EEG channel F8.	T	
7	When recording EPs, the spontaneous EEG is to be considered a noise that completely masks the EPs on the recorded waveform.	T	
8	The amplitude of an ERP is measured with respect to its value at the time of the event.	F	Amplitudes of ERPs are measured with respect to a baseline value, usually taken as the average of samples in a latency interval when no brain response is present.
9	Evoked brain activity is phase-locked to the stimulus to which it is a response.	T	
10	The alpha rhythm is said to be synchronized when the amplitude of its oscillations increase.	T	
11	The Shannon's theorem states that a continuous signal can be properly sampled only if it does not contain frequency components above the sampling rate.	F	The highest frequency component of the analog signal must be no higher than the Nyquist frequency, i.e. one half of the sampling frequency
12	Aliasing occurs when an analog signal is sampled outside the conditions set by the Shannon's theorem.	T	

13	An experimenter can reduce the chance of signal clipping by choosing a DAC with a lower number of bits.	F	Clipping occurs when the amplitude of the analog signal exceeds the input range of the ADC. A wider input range can be achieved by increasing the quantization interval, and/or by increasing the number of quantization levels ($L=2^{\text{NBITS}}$)
14	The RMS and the ARV of a zero-mean signal have the same value then the number of samples $N \rightarrow \infty$.	F	The RMS equals the variance σ^2 of a zero-mean signal.
15	In a gaussian noise, the probability density that a sample has a given amplitude value follows the normal distribution with zero mean.	T	
16	Windowing the signal with a Blackman-Harris window reduces the spectral leakage effect because it reduces the width of the main lobe of the spectrum.	F	A tapered windowing reduces the amplitude of spectral side-lobes, but increases the width of the main lobe.
17	Filters are categorized into four types depending on the basic shape of their frequency response: (i) low-pass; (ii) high-pass; (iii) low-stop; (iv) high-stop	F	
18	Order by ascending frequency of oscillations the following EEG rhythms: A. Alpha B. Beta C. Delta D. Gamma E. Theta	C, E, A, B, D	
19	Describe the main differences between gold and Ag/AgCl electrodes.	<text>	Ag/AgCl electrodes are non-polarizable, i.e. charges can freely flow from ionic conductor to metal conductor. Au electrodes are perfectly polarizable, i.e. a double layer of charges is established at the gel-metal interface, behaving as a capacitor. Thus Ag/AgCl is adequate for recording extremely slow or even DC potentials, while Au electrodes must only be used to measure fast-changing potentials.
20	Given 100 independent and identically distributed random variables with variance equal to 4, what is the variance of average?	0.04	$\sigma_{avg}^2 = \sigma^2 / N$

Section B

Wrong answers subtract half of the question's score from the total.

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