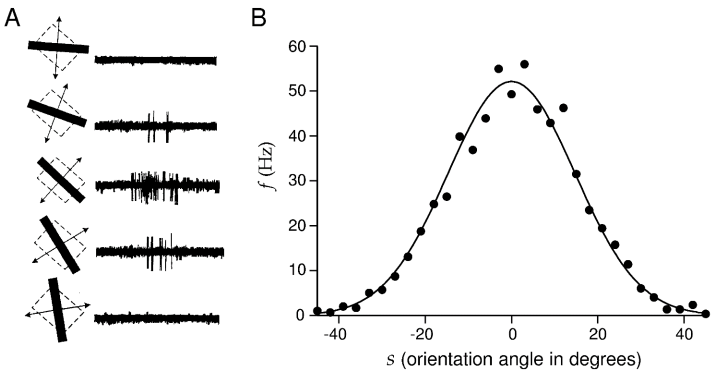
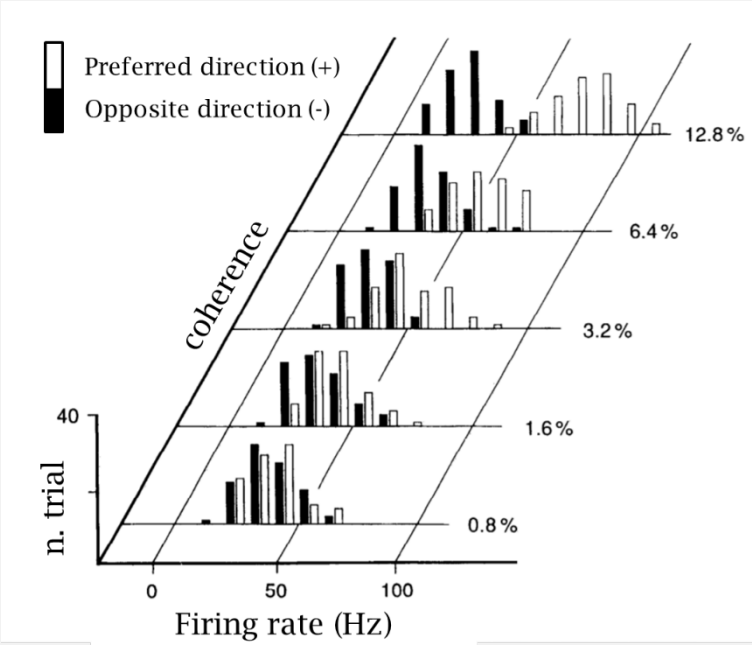
Neuroengineering 2020-2021

Exam 17 September 2021 – Part I

Solutions

Section A

	Question	Answer	Points (correct)	Points (wrong)
1	The voltage-gated Na^+ channel opening is responsible for the depolarization phase of the action potential.	T	0.5	-0.25
2	The voltage-gated K^+ channel is responsible for the relative refractory period.	T	0.5	-0.25
3	The part of the pyramidal neuron that acts as a current dipole is the axon.	F	0.5	-0.25
4	The firing rate influences the temporal summation of the PSPs.	T	0.5	-0.25
5	Each brain lobe can contain several Brodmann areas.	T	0.5	-0.25
6	The Penfield Homunculus has a somatotopic organization.	T	0.5	-0.25
7	The neurons' orientation affects the amplitude of the EEG signals they produce.	T	0.5	-0.25
8	To record *in vivo* measures of the membrane potential over the axon of a neural cell, you will use intracellular recordings.	F	0.5	-0.25
9	Potentials recorded by electrodes which are at a close distance on the scalp are mutually independent.	F	0.5	-0.25
10.	Given the following tuning curve, reporting the firing rate of a neuron of the primary visual cortex (B) in response to the orientation angle of a visual stimulus (A):  If the measured firing rate is 10 Hz, I can infer a univocal orientation angle that produced that response.	F	0.5	-0.25
11	In reference to the previous figure (question 10): from the curve I can conclude that there is a preferred stimulus orientation for which this neuron is designed to respond.	T	0.5	-0.25
12	In reference to the previous figure (question 10): there are stimulus orientation angles to which this neuron is "blind" (i.e., it doesn't show any response).	T	0.5	-0.25

13	In a Poisson process, when r increases, higher values of n are less likely.	F	0.5	-0.25
14	The difference between the distribution of *isi* (inter spike intervals) in real data and in simulated data produced by an uncorrected Poisson generator is due to the refractory periods.	T	0.5	-0.25
15	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:  Discriminability *d'* is higher when the coherence level is equal to 6.4% than when it is equal to 0.8%.	T	0.5	-0.25
16	In reference to the previous figure (question 15): the distribution (+) is less affected by the coherence level than the distribution (-).	F	0.5	-0.25
17	The Granger Causality Index G_{xy} is a multivariate estimator of brain connectivity.	F	0.5	-0.25
18	The $PDC_{xy}(f)$ between two time series *x* and *y* $\in[0, \infty]$. *Given the existence of the non-normalized version, T was also accepted as correct*	F*	0.5	-0.25
19	The Ordinary Coherence between two time series *x* and *y* is a function of the frequency.	T	0.5	-0.25
20	In a graph, the distance *d(i,j)* between two nodes is given by the average length of the paths that link them.	F	0.5	-0.25
21	In a graph, the Density $\in[0, 1]$.	T	0.5	-0.25
22	A regular network has fewer nodes than a random network.	F	0.5	-0.25
TOT			**11**	

Section B

	Question	Pts.	Ans.	Explanation
1	The frequency of oscillation of the beta rhythm is around 10 Hz	0.5	F	The minimum conventional oscillation frequency of the beta rhythm is 14 Hz
2	The oscillations of mu rhythm are more "arc-shaped", rather than resembling a regular sinewave	0.5	T	
3	The advantage of a high CMRR amplifier is that it suppresses common-mode disturbances such as powerline (50 Hz) noise.	0.5	T	
4	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	
5	Contact impedance of the electrodes can be measured using a direct (non-alternating) current.	0.5	F	Contact impedance is frequency dependent and must be measured with an alternating current in the same frequency range as the EEG.
6	The EEG electrode F8 is located to the left of electrode F7	0.5	F	In the International 10-20 System, labels with odd/even numbers are located over the left/right hemisphere
7	An eyeblink produces an artifact which often interferes with the analysis of the beta band of the EEG.	0.5	F	An eyeblink artifact is a slow wave lasting several tens of a second (i.e. well below 10 Hz)
8	Powerline noise is accentuated by asymmetries in the recording electrode pairs, such as impedances and cable path, because asymmetries prevent the noise to be rejected by the amplifier's common-mode rejection capabilities.	0.5	T	
9	Notch filters effectively remove powerline noise because they selectively reject the narrow band affected by the artifact, preserving almost entirely the useful signal.	0.5	T	
10	The potential at the peak of the EP component P20 is higher than the potential at the peak of the N100 component	0.5	T	

	Question	Pts.	Ans.	Explanation
11	One can never remove one of the channels from the raw EEG recording prior to analysis. Rather all epochs contaminated from artifacts will be rejected.	0.5	F	Artifact rejection should aim at minimizing the amount of data discarded. If removing a whole channels prevents discarding a large number of trials, this option should be considered.
12	Evoked brain activity is phase-locked to the stimulus to which it is a response.	0.5	T	
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	
14	In Analog to Digital Conversion, the Nyquist frequency equals half of the sampling frequency.	0.5	T	
15	Appropriate application of an analog filter (i.e. before the analog signal is converted) may prevent saturation by removing high amplitude artifacts in specific frequency bands.	0.5	T	
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 $s_X^2 = \frac{1}{N-1}\sum_i (x_i - \bar{X})^2$, 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	The synchronized average of N trials containing only spontaneous EEG whose $RMS_{trial} = \sigma^2$ is a signal $RMS_{avg} = \sigma^2/N$	0.5	T	True
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 Butterworth filter is a design method in the family of Finite Impulse Response filters	0.5	F	A Butterworth filter is a IIR filter.
22	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	0.5	T	True
	Total points	**11**		