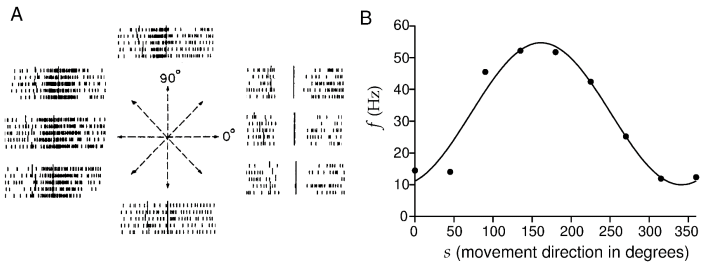
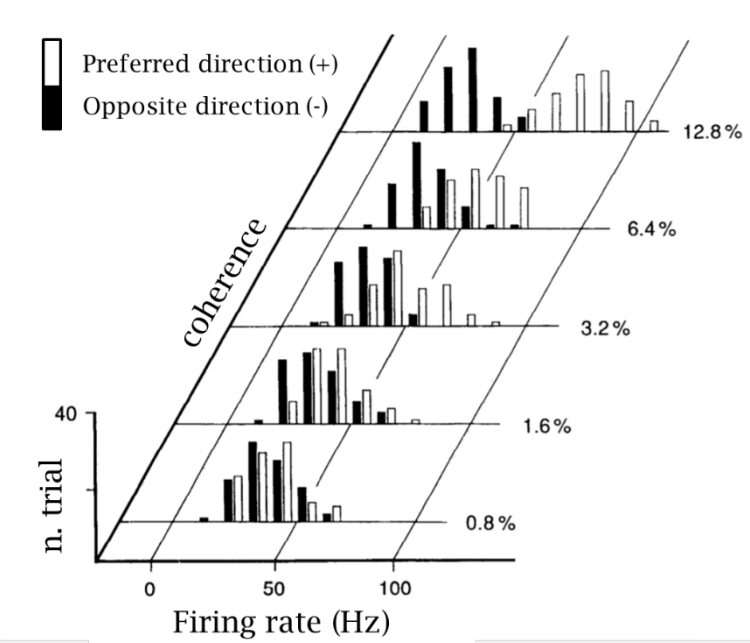
Neuroengineering 2019-2020

Exam 18 January 2021 – Part I

Solutions

Section A

	Question	Answer	Points (correct)	Points (wrong)
1	The voltage-gated K^+ channel inactivation state is responsible for the absolute refractory period.	F	0.5	-0.25
2	The voltage-gated Na^+ channel is responsible for the repolarization phase of the action potential.	F	0.5	-0.25
3	Temporal and spatial summation can occur simultaneously.	T	0.5	-0.25
4	The firing rate influences the amplitude of the resulting action potential in the post-synaptic cell.	F	0.5	-0.25
5	The long-term synaptic plasticity involves a structural change in the post-synaptic membrane.	T	0.5	-0.25
6	The brain operates at the temporal scale of milliseconds.	T	0.5	-0.25
7	The synchronicity of the neural activity affects the amplitude of EEG signals.	T	0.5	-0.25
8	Scalp EEG is mainly produced by the deep (subcortical) regions.	F	0.5	-0.25
9	The electrical variation of the membrane potential that mainly contributes to EEG is the action potential.	F	0.5	-0.25
10.	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:  When the firing rate is 55 Hz, I can infer which movement direction produced that response.	T	0.5	-0.25
11	In reference to the previous figure (question 10): from the curve I can conclude that this neuron is tuned to be active in correspondence to a given movement direction.	T	0.5	-0.25
12	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	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 a 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:  Discriminability *d'* is higher when the coherence level is equal to 1.6% than when it is equal to 6.4%.	F	0.5	-0.25
16	In reference to the previous figure (question 15): the distribution (+) is more affected by the coherence level than the distribution (-).	T	0.5	-0.25
17	The Partial Directed Coherence (PDC) is a multivariate estimator of brain connectivity.	T	0.5	-0.25
18	Given the Ordinary Coherence $C_{xy}(f)$ between two time series *x* and *y*, $C_{xy}(f) \in [0, \infty]$.	F	0.5	-0.25
19	Given the Granger Index G_{xy} between two time series *x* and *y*, G_{xy} is a function of the frequency.	F	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 Global Efficiency $\in [0, 1]$.	T	0.5	-0.25
22	A small-world network has fewer nodes than a regular network.	F	0.5	-0.25
TOT			**11**	

Section B

	Question	Pts.	Ans.	Explanation
1	The “waxing and waning” of the alpha rhythm is a change of amplitude occurring about 10 times a second.	0.5	F	The oscillation of the alpha rhythm occurs approximately 10 times a second. On the other hand, “waxing and waning” describes the amplitude modulation of the rhythm, which occurs about an order of magnitude more slowly.
2	The CMRR is usually expressed in decibel (dB) and high values characterizes better amplifiers.	0.5	T	
3	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	
4	An artifact is a potential difference due to sources outside the brain.	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	Sweating can affect the EEG, causing an increase of contact impedance and an increase of powerline noise	0.5	F	Sweating causes a slow changing and high amplitude artifact (below 0.5 Hz, up to a few mV)
9	Notch filters effectively remove powerline noise because they reject all signals above their corner frequency.	0.5	F	Notch filters selectively reject the narrow frequency band affected by the artifact
10	The alpha rhythm is said to be synchronized when the amplitude of its oscillations increase.	0.5	T	

	Question	Pts.	Ans.	Explanation
11	Synchronized averaging of N EEG trials produces N values each corresponding to the average value of the potential in each trial.	0.5	F	The number of samples of the waveform obtained by synchronized averaging is independent of the number N of trials (it equals the number of samples in each trial).
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 the amount of coupling between signals on two EEG channels.	0.5	F	ERD/S quantify changes of the power of EEG relative to a baseline period
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	Quantization divides the input range of the ADC into (approximately) $NBITS$ intervals, where NBITS is the number of bits of the ADC.	0.5	F	Quantization divides the input range of the ADC into (approximately) 2^{NBITS} intervals
17	The RMS and the standard deviation of a zero-mean signal have the same value (assume that the number of samples $N \to \infty$).	0.5	T	
18	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
19	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.	0.5	F	IIR filters cannot be designed to have liner phase
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 FIR	0.5	F	The Butterworth filter is an Infinite Impulse Response (IIR) filter
22	The amplitude of sensorimotor rhythms can be voluntarily modulated through the exercise of motor imagery, to build a cursor control based on a BCI.	0.5	T	True
	Total points	**11**		