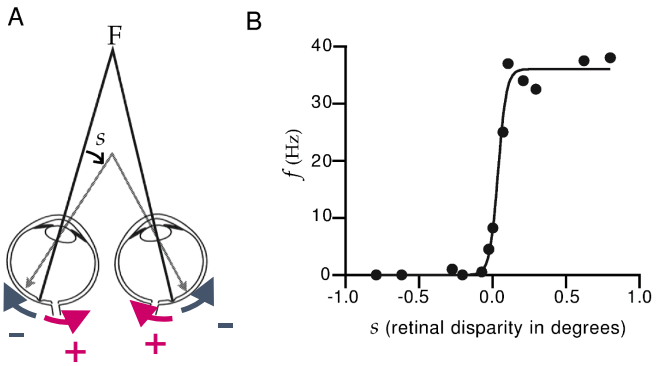
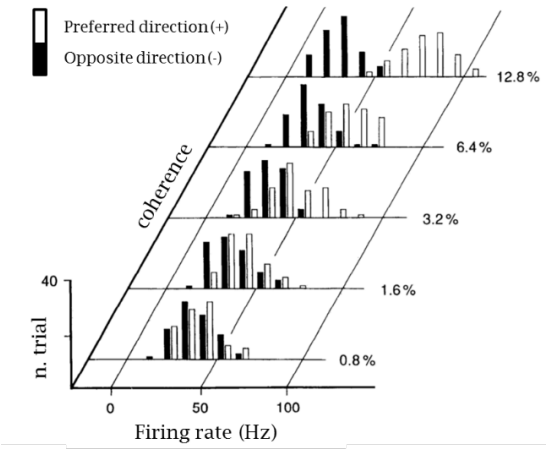
Neuroengineering 2021-2022

Exam January 11th 2023 – Part I

Solutions

Section A

	Question	Ans.	Explanation
1	Temporal and spatial summations can occur simultaneously.	T	
2	The voltage-gated Na^+ channel is responsible for the absolute refractory period.	T	
3	The most informative parameter of the spike train in output to a neuronal cell is the amplitude of the spikes.	F	*All the spikes have the same amplitude, so this is not an informative parameter.*
4	The firing rate of the pre-synaptic neuron influences the temporal summation of the PSPs in the post-synaptic cell.	T	
5	The primary visual area is located in the cortex.	T	
6	In the brain primary motor cortex (Penfield homunculus) the extension of the cortical region which controls a specific body region is proportional to that body region's volume.	F	*The extension of the cortical region which controls a specific body region is proportional to the number of motor nerves, not to the body region's volume.*
7	The short-term synaptic plasticity involves an irreversible change in the post-synaptic membrane.	F	*The short-term changes are temporary.*
8	To record in vivo measures of the membrane potential over the axon of a single neural cell, you will use extracellular measures.	T	
9	The EEG signal is mainly generated by action potentials.	F	*It is mainly generated by post-synaptic potentials.*
10	The tuning curve in the figure shows (panel B) the firing rate *f* of a neuron in the primary visual cortex as a function of the retinal disparity angle *s* (panel A).  From the figure, we can infer that the neuron responds mainly to negative *s* (closed-tuned neuron).	F	*The firing rate is greater than zero only for positive s (far-tuned neuron)*

11	In reference to the previous figure (question 10): from the curve, if the neuron firing rate is equal to 0 Hz I can exactly infer which retinal disparity produced that response	F	*The retinal disparity in degrees cannot be inferred when the firing rate is equal to 0, because a large range of negative values would produce the same response.*
12	In a Poisson process, when *r* increases, higher values of *n* are more likely	T	
13	The differences between the distribution of *isi* in real data and in simulated data produced by an (uncorrected) Poisson spike generator are due to the refractory periods	T	
14	Given the distribution of firing rates in the figure:  The discriminability *d'* when the coherence=3.2% is higher than when it's =12.8%	F	*The discriminability d' is higher for higher values of the coherence level.*
15	In reference to the previous figure (question 14), among the two distributions (r_+ or r_-), r_+ is the one affected by the coherence level	T	
16	The normalized Partial Directed Coherence ∈ [0, +∞]	F	*It ∈[0,1]*
17	The Granger Test is more suitable than the Ordinary Coherence to obtain a spectral measure	F	*The Granger Test is not a spectral measure.*
18	If Cxy(f) is the ordinary coherence between x and y, Cxy(f)=Cyx(f)	T	
19	The difference between the Wiener's and Granger's definitions of causality in the statistical sense is that Granger indicated a modeling framework to be used to test causality	T	
20	Regular networks have a smaller Global Efficiency than random networks	T	
21	Regular networks have a smaller Local Efficiency than random networks	F	*They have a larger Local Efficiency.*
22	Undirected graphs produce symmetrical adjacency matrices	T	

Section B

	Question	Pts.	Ans.	Explanation
1	In the EEG terminology, impedance is a measure of the ability of an experimental subject to carry on an experiment.	0.5	F	True
2	The advantage of a high CMRR amplifier is that it suppresses common-mode disturbances such as powerline (50 Hz) noise.	0.5	T	True
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	True
4	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
5	Evoked Potentials are deflection of the EEG signal following the presentation of a sensory input.	0.5	T	True
6	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
7	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.
8	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
9	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/convienient artifacts should be avoided at recording time.
10	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

	Question	Pts.	Ans.	Explanation
11	In analog-to-digital conversion, each spectral component of the analog signal should have frequency below the Nyquist frequency.	0.5	T	True
12	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval: $\sigma_{quant} = 1/\sqrt{12}\ LSB$	0.5	T	True
13	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
14	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 *induced*.	0.5	T	True
15	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
16	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.*]
17	Given 100 independent and identically distributed random variables with variance equal to 4, the variance of their average is 0.04?	0.5	T	$\sigma_{avg}^2 = \sigma^2/N$
18	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
19	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
20	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
21	A BCI is a system that measures brain activity and converts it to an artificial output.	0.5	T	True
22	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
	Total points	**11**		