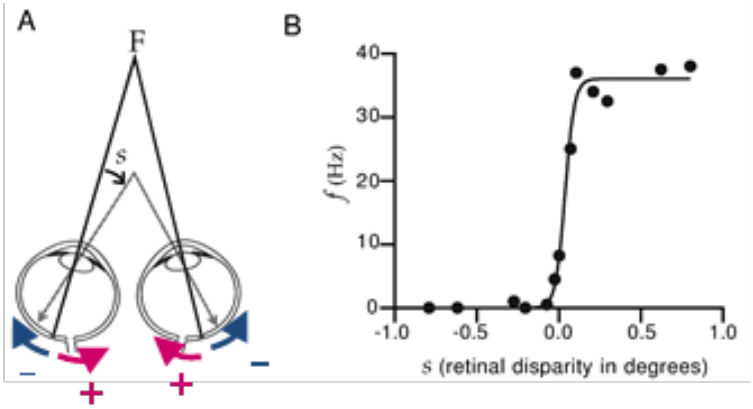
Neuroengineering 2023-2024

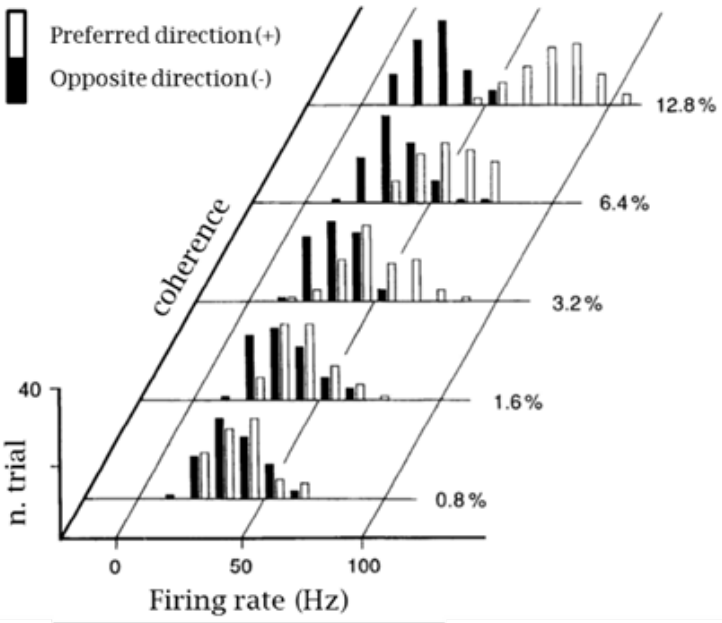
Exam 3 July 2024 – Part I (even)

Solutions

Section A

#	Question	Ans.	Explanation
1	An IPSP consists of a depolarization of the post-synaptic cell membrane.	F	*Being inhibitory, it consists of a hyperpolarization of the membrane.*
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	*The amplitude of all the spikes is the same, 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 frontal lobe houses the primary visual function.	F	*The primary visual cortex is located in the occipital lobe.*
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.*

#	Question	Ans.	Explanation
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 positive *s* (far-tuned neuron).	T	
11	In reference to the previous figure: 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	To record in vitro measures of the membrane potential over the dendrites of a neural cell, you will use extracellular measures	F	*Extracellular measures are able to capture only the sequence of APs, not the E/IPSPs that occur over the dendrites. To this purpose, we will use intracellular recordings.*
13	The part of the pyramidal neuron that acts as a current dipole is the axon	F	*It's the dendritic tree.*

#	Question	Ans.	Explanation
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, among the two distributions (r_+ or r_-), r_+ is the one affected by the coherence level	T	
16	The normalized Partial Directed Coherence $\in[0, 1]$	T	
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	A regular network has fewer nodes than a random network.	F	*We can define regular and random networks of any dimension (number of nodes).*
22	Random networks have a smaller Local Efficiency than regular (lattice) networks.	T	

#	Question	Ans.	Explanation
23	In a graph, the minimum Divisibility is equal to zero.	F	*According to the most used normalization, the minimum Divisibility is equal to 0.5. More generally, even with different choices of the term k, D can never be equal to zero.*
24	Divisibility and Modularity are measures of integration of a network.	F~~T~~	*Divisibility and Modularity are measures of segregation.*

Section B

#	Question	Ans.	Explanation
1	In a P300-based BCI, the user subjectively assigns saliency (relevance) to a stimulus so that their brain produces a P300 ERP every time the stimulus is administered	T	TRUE
2	Event-Related Desynchronization/Synchronization (ERD/S) quantify phase-locked brain activity in response to an event	F	Event-Related Desynchronization/Synchronization (ERD/S) quantify relative changes of the power of the EEG rhythm in a predefined frequency range; phase locked activity is estimated using the synchronized averaging.
3	A FIR filter needs to be of a higher order to achieve the same quality specifications than a IIR filter.	T	TRUE
4	The N20 component of an EP occurs before the stimulus (negative latency) while the P300 occurs after the stimulus (positive latency).	F	'N' and 'P' indicate the sign of the amplitude of the ERP (Negative and Positive, respectively), not the latency.
5	EEG signals recorded in monopolar configuration can be re-referenced to the Common Average Reference (CAR), by subtracting from each channel the instantaneous average of all channels. In ideal conditions, this would approximate taking the reference potential at infinity.	T	TRUE
6	Evoked Potentials are deflection of the EEG signal following the presentation of a sensory input.	T	TRUE
7	When recording EPs, the spontaneous EEG is to be considered a noise that completely masks the EPs on the recorded waveform.	T	True. With very rare exceptions (mostly in the field of pathology) EPs are one or more orders of magnitude smaller than the spontaneous EEG.
8	In ERP analysis, 'trials' are portions of the continuous EEG recording that start exactly at the time when a sensory stimulus was delivered	F	The start of a trial usually precedes the time of the event, so that a pre-stimulus baseline period can be analyzed. Events are not necessarily sensory stimulations.

#	Question	Ans.	Explanation
9	Aliasing occurs when an artifact corrupts an otherwise healthy EEG recording.	F	Aliasing occurs when the sampling frequency of an analog signal is lower than twice the frequency of any spectral component of the signal
10	The roll-off of a filter is the slope of its frequency response in the transition band. It is high when the transition band is narrow.	T	TRUE
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 signal must not contain spectral components above *half* the sampling rate (Nyquist frequency)
12	The contact impedances of a pair of electrodes should be large compared to the input impedance of the differential amplifier connected to them, otherwise the amplitude of the signal would be reduced as effect of the potential divider.	F	False, the contact impedances must be *lower* than the amplifier's input impedance, mainly to help keeping the circuit balanced (higher CMRR)
13	The CMRR of an EEG amplifier should be higher than 90 dB	T	TRUE
14	Movements of the subject's head produces artifacts only in the gamma band.	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
15	The powerline noise affects a very narrow frequency band of the recorded signal around 50 Hz (in Europe) and odd multiples of (150 Hz, 250 Hz, …).	T	TRUE
16	A 'run' is a portion of recording in an experimental protocol that contains no breaks, i.e. all samples contained therein have been acquired $1/f_s$ seconds after the previous (f_s being the sampling frequency)	T	TRUE
17	$ARV_x = \sqrt{\frac{1}{N}\sum_i (x[i])^2}$, where the sum extends on the N samples of the signal x[i]	F	$ARV_X = \frac{1}{N}\sum_i \lvert x_i \rvert$, ARV being the acronym of Average Rectified Value
18	The frequency spectrum of white noise is flat, i.e. it has the same power at any frequency.	T	TRUE

#	Question	Ans.	Explanation
19	An EEG recording is said to be bipolar when it comprises exactly two channels	F	In bipolar EEG recordings, each channel is the difference of potential between two (adjacent) electrodes. The number of channels is not relevant
20	The RMS and the ARV of a zero-mean signal have the same value (assume that the number of samples $N \to \infty$).	F	For a zero-mean signal, the RMS equals the standard deviation σ of a zero-mean signal.
21	Event-Related Desynchronization/ Synchronization (ERD/S) quantify the amount of coupling between signals on two EEG channels.	F	ERD/S quantify changes of the power of EEG relative to a baseline period
22	In an ADC, quantization introduces a noise whose amplitude is proportional to the width of the quantization interval (V_{LSB}): $\sigma_{quant} = \frac{1}{\sqrt{12}} \cdot V_{LSB}$	T	TRUE
23	The Short Time Fourier Transform (STFT) is a simple method to estimate a spectrogram, i.e. the representation of the time-varying spectrum of a non-stationary signal.	T	TRUE
24	The mu rhythm and the alpha rhythm are EEG components that differ for their fundamental frequency of oscillation	F	They both oscillate around 10 Hz.