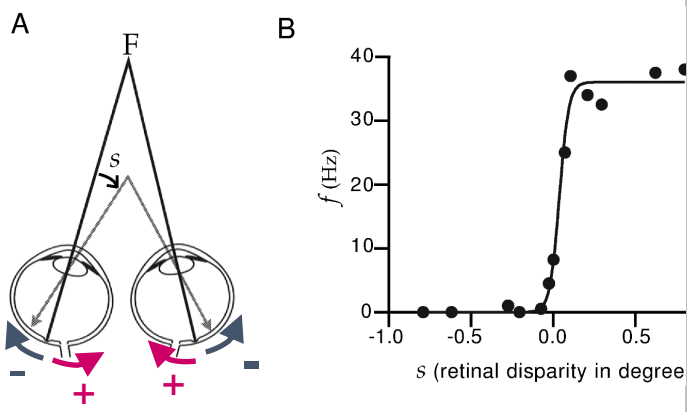
Neuroengineering 2021-2022

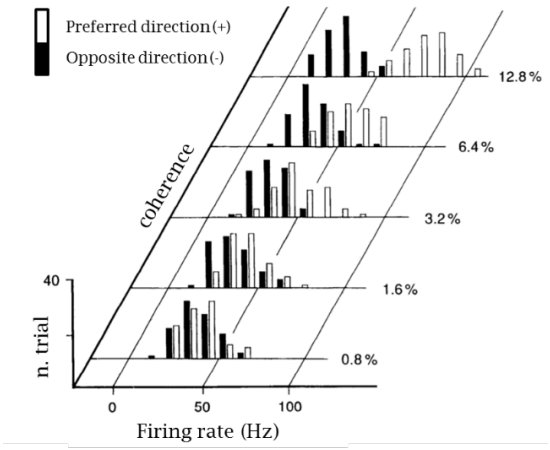
Exam 15 September 2022 – Part I

Solutions

(updated 30/09/2022 12:30)

Section A

	Question	Ans.	Explanation
1	We need to measure the amplitude and duration of an action potential each time it occurs to understand the cell behavior.	F	The amplitude and duration are the same for all APs.
2	The neuronal resting membrane potential is given by the sum of diffusional forces, electrical forces, and ion pumps activity	T	
3	The propagation of the action potential in myelinated axons is faster than the one in unmyelinated axons	T	
4	The visual function is located in the brain frontal lobe	F	It is located in the occipital lobe.
5	The thalamus is a cortical region	F	It is subcortical.
6	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 he E/IPSPs that occur over the dendrites. To this purpose, we will use intracellular recordings.
7	The part of the pyramidal neuron that acts as a current dipole is the axon	F	It's the dendritic tree.
8	The neurons' spatial orientation affects the amplitude of EEG signals	T	
9	The post-synaptic potentials are the electrical variation of the membrane potential that mainly contributes to EEG	T	
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 only to positive s (far-tuned neuron)	T	

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	Around 0 the firing rate swiftly moves between the two values that we can associate to a positive or retinal disparity.
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 a 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=1.6 is higher than when it's =12.8	F	The discriminability increases with the coherence.
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 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	
17	If Cxy(f) is the ordinary coherence between x and y, Cxy(f)=Cyx(f)	T	
18	The normalized Partial Directed Coherence $\in[0, \infty]$	F	$\in[0, 1]$
19	The Granger Test is more suitable than the Ordinary Coherence to obtain a spectral measure	F	GC is not a spectral measure. OC is.
20	Regular networks have a smaller Global Efficiency than random networks	T	
21	Regular networks have a smaller Local Efficiency than random networks	F	Regular networks have a high Local Efficiency (higher than Regular ones).
22	Undirected graphs produce symmetrical adjacency matrices	T	

Section B

	Question	Pts.	Ans.	Explanation
1	The theta rhythm includes oscillations with a frequency of 5 Hz	0.5	T	
2	With respect to the alpha rhythm, the oscillations of mu rhythm are more "arc-shaped", rather than resembling a regular sinewave	0.5	T	
3	The measurement of a single EMG signal requires three electrodes – two as input to the differential amplifier and one to provide the ground potential.	0.5	T	
4	The input impedance of a biosignal amplifier must be many orders of magnitude higher than the contact impedance of the electrodes	0.5	T	
5	The International 10-20 System for EEG electrodes placement takes its name from the fact that it describes the standard position of a set of at least 10 and up to 20 electrodes.	0.5	F	10% and 20% are fractions of the total distance between craniometric points, used to establish electrode positions.
6	Artifacts on biosignal recordings cannot have biological origin.	0.5	F	Artifacts can have biological origin (such as eyes, muscles heart), can be due to external electromagnetic generators (power supply, engines, etc) or to events affecting the recording setup (electrode movements or loss of contact, saturation of the ADC).
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	EMG artifacts on a EEG recording mainly affects the alpha band and specifically the mu rhythm.	0.5	F	EMG artifacts has a spectral content starting at frequencies of 20 Hz and up, thus affecting the beta and gamma bands of the EEG signal
9	EMG artifact can easily appear on the EEG recording unless the subjects are specifically instructed by the experimenter on how to relax their face muscles.	0.5	T	
10	The estimation of ERPs requires the acquisition of numerous repetitions of the stimulus or event which evoked or induced the potential.	0.5	T	
11	The potential at the peak of the EP component N20 is lower than the potential at the peak of the P100 component	0.5	T	P100 is a positive peak, N20 is a negative peak. The potential of the former is thus higher.

	Question	Pts.	Ans.	Explanation
12	Induced activity is best analyzed by applying synchronized averaging to the EEG trials.	0.5	F	Synchronized averaging enhances evoked (phase-locked) components, not induced (non-phase-locked) components of the EEG.
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	The Nyquist frequency is the highest frequency of a component in an analog signal.	0.5	F	The Shannon theorem mandates that this is the case, but the Nyquist frequency is defined as half the sampling frequency
15	Aliasing occurs when an artifact corrupts an otherwise healthy EEG recording.	0.5	F	Aliasing occurs when the sampling frequency of an analog signal is lower than twice the frequency of any spectral component of the signal
16	Aliasing can be prevented by applying a digital low-pass filter with cutoff frequency lower than the Nyquist frequency.	0.5	F	Aliasing must be prevented by applying an analog filter before ADC. Digital filters can only be applied after the signal is sampled, and thus aliasing has occurred. No digital filter can remove it at that point.
17	$ARV_X = 1/N \sum_i x_i^2$, where the sum extends on the N samples of the signal X	0.5	F	$ARV_X = 1/N \sum_i \lvert x_i \rvert$,, ARV being the acronym of Average Rectified Value
18	The frequency spectrum of a gaussian noise is flat, i.e. it has the same power at any frequency.	0.5	F	Not necessarily. A gaussian noise has normal distribution of amplitude of the samples. [*A white noise has a flat spectrum.*]
19	Given 100 independent and identically distributed random variables with variance equal to 4, the variance of their average is 0.4?	0.5	F	$\sigma_{avg}^2 = \sigma^2/N = 4/100 = 0.04$ (not $\sqrt{N}$)
20	The higher the sampling frequency of a digital signal, the higher the frequency resolution of its spectrum.	0.5	F	The frequency resolution of a spectrum is only determined by the duration of the signal. A change of sampling frequency alone only affects its frequency range.
21	A FIR filter needs to be of a higher order to achieve the same quality specifications than a IIR filter.	0.5	T	
22	The P300 ERP generated by attending a target stimulus is exploited to build virtual keyboards based on a BCI	0.5	T	
	Total points	**11**		