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Brandenburgische
Technische Universität
Cottbus - Senftenberg

Introduction to Neural Signal Analysis Exam

Winter Semester 2023/2024

Student First Name:

Date: 21.03.2024

Student Last Name:

Duration: 2 hours

Student ID:

Instructor: Zahra Shirzhiyan

Please carefully read the questions and mark the correct answer on the answer sheet provided. Ensure that the letter on the most upper left side of the question sheet and answer sheet match precisely.

There are 30 questions to be answered, each carrying equal weight, with only one correct answer per question. Please be advised that only the answer sheet will be assessed.

Questions:

1. Which phase of the action potential is primarily characterized by the rapid influx of sodium ions, leading to membrane depolarization?

A) Threshold

B) Rising phase

C) Overshoot

D) Falling phase

2. What is the primary mechanism by which an excitatory postsynaptic potential (EPSP) leads to membrane depolarization?

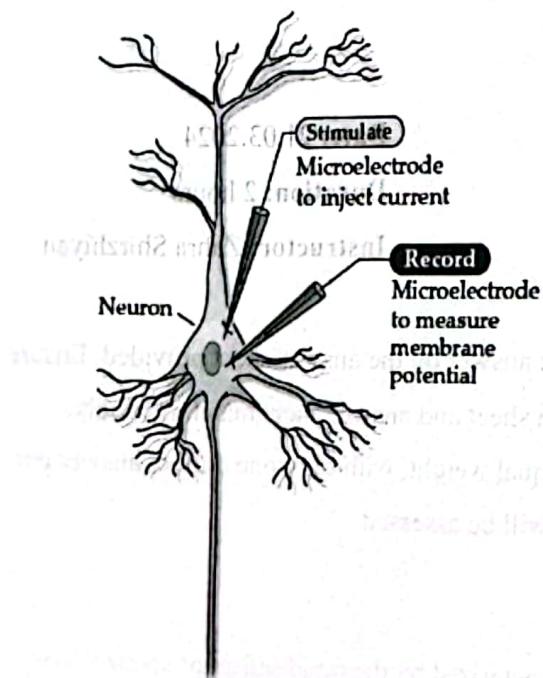
A) Activation of voltage-gated potassium channels

B) Activation of voltage-gated sodium channels

C) Inhibition of voltage-gated calcium channels

D) Inhibition of ligand-gated ion channels

3. According to the figure, two microelectrodes are inserted into a neuron; one for stimulation and another for recording. Which statement accurately describes the relationship between injected current and action potential generation?



- A) Injected current below threshold leads to decreased action potential firing rate.
- B) Injected current above threshold results in decreased action potential firing rate.
- C) Injected current at threshold leads to no action potential generation.
- D) Injected current beyond threshold leads to increased action potential firing rate.

4. Which ion transport mechanism requires metabolic energy to move ions against their concentration gradients?

- A) Leak channels
- B) Ion pumps
- C) Voltage-gated channels
- D) Ligand-gated channels

5. Which of the following statements is TRUE about the generation of action potentials in neurons?

- A) Action potentials can be generated in any part of the neuron, including dendrites and cell bodies.

- B) Action potentials are typically generated at the axon hillock, where voltage-gated sodium channels are abundant.
- C) In most sensory neurons, action potentials are generated at the axon hillock in response to synaptic input.
- D) The spike-initiation zone, where action potentials are typically generated, is located at the dendrites of neurons.

6. Which of the following brain regions is primarily responsible for the perception and analysis of sound characteristics such as pitch, frequency, and location?

- A) Auditory Association cortex
- B) Wernicke's Area
- C) Primary Olfactory cortex
- D) Primary auditory cortex

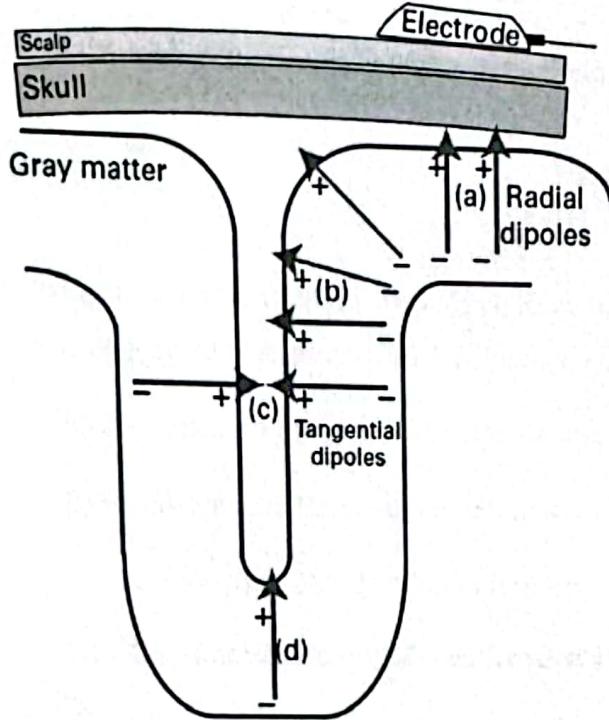
7. Which of the following functions are primarily associated with the parietal lobe of the brain?

- A) Language comprehension and production
- B) Perception and analysis of sound characteristics
- C) Analysis and recognition of somatic sensations such as pressure and vibration, spatial coordination, and multi-modal association
- D) Perception and recognition of olfactory sensations

8. Which statement is TRUE about electrical synapses?

- A) Electrical synapses involve the release of neurotransmitters across a synaptic cleft.
- B) Electrical synapses occur at specialized sites called synaptic vesicles.
- C) Transmission at electrical synapses is slow due to the involvement of neurotransmitter diffusion.
- D) Electrical synapses allow for direct transfer of ionic current between cells through gap junctions formed by connexins.

9. What is the role of pyramidal cells in generating the electrical field recorded by EEG?
- A) Pyramidal cells primarily contribute inhibitory postsynaptic potentials (IPSPs) to the formation of the electrical field.
 - B) Pyramidal cells are not involved in generating the electrical field recorded by EEG.
 - C) Pyramidal cells primarily contribute excitatory postsynaptic potentials (EPSPs) to the formation of the electrical field.
 - D) Pyramidal cells are responsible for directly generating action potentials recorded by EEG.
10. Which statement describes the strengths of EEG?
- A) EEG provides a direct measure of neurotransmitter levels in the brain.
 - B) EEG has low temporal resolution, limiting its ability to capture rapid changes in brain activity.
 - C) EEG recordings require exposure to radiation or high magnetic fields.
 - D) EEG devices can be made small and portable, allowing for easy use in various environments.
11. Which dipole orientation is most likely to contribute the strongest signal to EEG recordings, according to the provided information?



A) Dipole (a)

B) Dipole (b)

C) Dipole (c)

D) Dipole (d)

12. What is the purpose of using silver electrodes with a silver chloride coating in bio-potential measurements?

- A) To increase electrode capacitance at the solution interface
- B) To facilitate the transition from electronic to ionic conduction
- C) To reduce electrode capacitance at the solution interface
- D) To minimize the specificity of electrode potential

13. According to the information provided, what is a crucial consideration when determining the sample rate for signal acquisition?

- A) The amplitude resolution of the analog-to-digital converter (ADC)
- B) The number of bits used in the digital representation of the signal
- C) The frequency content of the signal being sampled
- D) The type of filter used to attenuate undesired frequency components

14. What term is used to refer to the minimum sampling rate required to accurately represent a signal, which is half of the sampling rate?

- A) Nyquist frequency
- B) Aliasing frequency
- C) Sampling frequency
- D) Bandwidth frequency

15. What do the numbers "10" and "20" in the International 10–20 System refer to?

- A) The distance between electrodes on the edges of the scalp and the horizontal line connecting the Nasion to the Inion
- B) The distance between each electrode and the vertex point on the scalp
- C) The percentage values used to position electrodes along the scalp
- D) The distance between adjacent electrodes on the scalp

16. Which statement accurately describes the role of the differential amplifier in EEG signal acquisition?

- A) The differential amplifier amplifies the electrical potential of the scalp relative to the ground of the acquisition circuit.
- B) The differential amplifier amplifies the voltage difference between two electrodes on the scalp and eliminates common noise affecting the ground of both measures.
- C) The differential amplifier cancels out noise from muscular origins.
- D) The differential amplifier serves as a reference point for the neural activity.

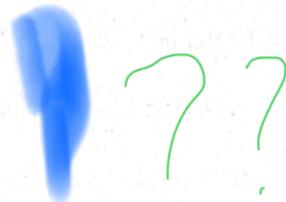
17. What condition must be satisfied in the frequency domain to avoid overlap in the spectra of the sampled signal?

- A) The maximum value of the spectrum of the sampled signal must be less than F_s .
- B) The maximum value of the spectrum of the sampled signal must be less than $F_s/2$.

- C) The maximum value of the spectrum of the sampled signal must be greater than F_s .
- D) The maximum value of the spectrum of the sampled signal must be greater than $F_s/2$.

18. What is the precision and maximum frequency for a EEG signal recorded over a 20-second interval and sampled at an interval of 1 millisecond (0.001 seconds)?

- A) Precision: 0.1 Hz , Maximum frequency: 1000 Hz.
- B) Precision: 0.05 Hz , Maximum frequency: 1000 Hz.
- C) Precision: 0.05 Hz , Maximum frequency: 2000 Hz.
- D) Precision: 0.1Hz , Maximum frequency: 2000 Hz.



19. What is identified as the number one enemy in recordings of biopotentials due to its nonrandom nature and potential to interfere with signal averaging results?

- A) Random noise
- B) Systematic bias
- C) Artifacts from switching instruments
- D) Hum

20. Which assumptions are typically made when employing signal averaging as a data analysis technique?

- A) Signal and noise are correlated.
- B) The timing of the signal is unknown.
- C) The signal component varies between repeated measurements.
- D) The noise is truly random with zero mean.

21. What is one of the principal motivations for employing signal averaging?

- A) To enhance the power of the time-locked component.

- B) To increase the randomness of the noise.
- C) To align the averages with the real trigger.
- D) To destroy the time-locked aspect of the epochs.

22. In scenarios where the noise is not random and exhibits periodic components, which strategy can help mitigate the undesired effects in the average?

- A) Using a larger stimulus interval
- B) Applying a low-pass filter to the signal
- C) Randomizing the stimulus interval
- D) Increasing the sampling rate

23. About background EEG characteristics which statement is true?

- A) Long-term EEG signals are always stationary time series.
- B) Short-term EEG signals can be considered stationary.
- C) The frequency range of EEG signals is typically below 0.01 Hz.
- D) EEG signals have constant amplitudes across all frequency bands.

24. Which method is suggested for removing line noise from recorded EEG signals without damaging background spectral components?

- A) High-pass filtering above 50 Hz
- B) Notch filtering with a narrow frequency width
- C) Multi-taper decomposition combined with regression modeling
- D) Applying a low-pass filter below 50 Hz

25. What solution is suggested to address potential issues with outlier channels when using the Common Average Reference (CAR) method?

- A) Amplify the signals from outlier channels
- B) Ignore the outlier channels during EEG analysis
- C) Detect and remove bad channels before applying the CAR method
- D) Use a different reference signal for outlier channels.

26. Which method in noise estimation can be used to estimate residual noise by using the same epochs as those in the "true" average?

- A) Bootstrap method
- B) Averaging of prestimulus epochs
- C) Inverting every other trial
- D) High-pass filtering

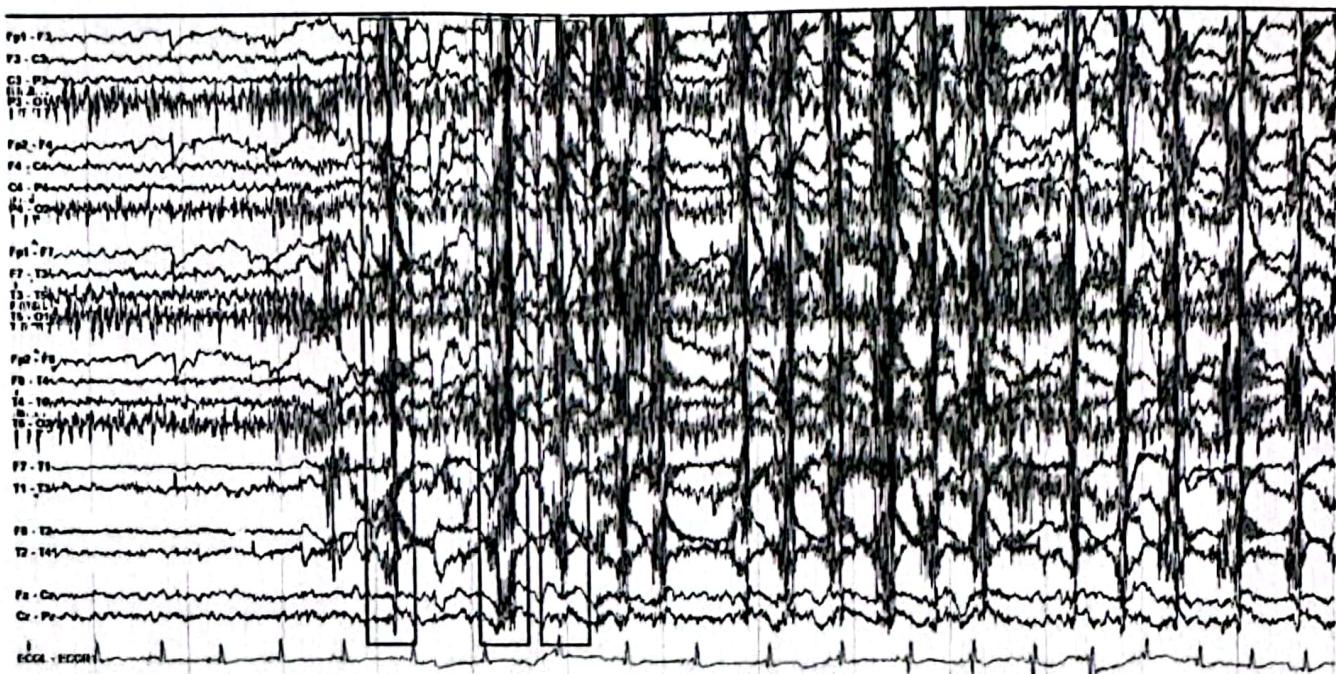
27. In correlation-based bad channel detection, what characteristic of normal EEG signals is used as a reference?

- A) High-frequency correlations
- B) Low-frequency correlations
- C) Mid-frequency correlations
- D) No correlations

28. Which method of interpolation provides accurate scalp potential estimation with dense electrode mapping?

- A) Higher-order polynomials
- B) Spherical splines
- C) Nearest-neighbor averaging
- D) Radial basis function

29. What kind of artifact is more detectable in the following figure:



A: Chewing artifact, temporalis muscles

B: Hypoglossal artifact, tongue movement

C. Cardioballistic artifact

D. Bad channels artifact

30. About ECG artifact, which statement is correct?

A) ECG artifact is not time-locked to any specific event on the ECG tracing.

B) ECG artifact tends to be more prominent on the right side due to the heart's location in the right half of the chest.

C) ECG artifact is characterized by high amplitude waveforms.

D) ECG artifact is time-locked to the QRS complex on the ECG tracing and tends to be more prominent on the left side.

Good Luck!

Zahra Shirzhiyan