

*Choose 4 out of the following 5 questions to answer. You may respond in Chinese or English. (100 points total, 25 points each question)*

1. Principles of Cognitive Neuroscience (25 points total)

a) Karl Lashley found that maze memory performances in the rats were largely the same no matter where lesions were applied in the brain. Lashley therefore concluded that memory was stored in a distributed manner across the brain rather than in localized brain regions. Discuss whether you think memory is distributed in the cortex or localized. Be sure to state the reasons for your view clearly. You may bring in findings from other studies in support of your case. (13 points)

b) Describe the Hebbian learning rule. How does this rule explain how neurons learn to form associations between two stimuli? Give an example to illustrate your answer. For example, you can describe what happens hypothetically at the neuronal level when an organism sees a circle stimulus and in conjunction smells a sweet fragrance over several trials. (12 points)

2. Cognitive Neuroscience of Vision (25 points total)

a) A point of light is presented in the upper right quadrant of a screen in front of a cat with its eyes fixated on the center of the screen. Electrodes in the cat's brain detect that neuron A in the lower section of the left hemisphere primary visual cortex showed rapid electrical spiking activity. The light is moved a little lower on the screen but still in the upper right quadrant. Neuron A stops spiking but neuron B just next to it and also in the lower section of the left hemisphere primary visual cortex begins rapid spiking activity. What does this phenomena demonstrate about the sensitivity of primary visual neurons to visual stimuli in adjacent locations? (3 points)

b) The light is then moved to the lower left quadrant of the screen and neurons A and B stop spiking, but neuron C located in the upper section of the right hemisphere primary visual cortex starts spiking. What does this demonstrate about the organization of primary visual neuron responses with respect to the visual environment? (3 points)

c) Neuron D is located in the left inferior temporal lobe and shows spiking activity to the point of light on all locations on the screen, but does not spike when the light is turned off. Explain in detail how this can occur by describing the nature of connections from neurons in the primary visual cortex to neurons in the inferior temporal lobe. (8 points)

d) It has been suggested that the higher visual system is organized into a ventral "what" stream involving the temporal cortex and a dorsal "where" stream involving the parietal cortex. Explain in detail what this organization means in terms of the kinds visual information processed by these two streams. You may use examples to illustrate your points. (6 points)

e) Do the "what" and "where" streams fully account for the way human beings process visual information? Why or why not? (5 points)

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**3. Cognitive Neuroscience of Language (25 points total)**

a) Broca's Area is a well-known brain region involved in language processing. State this brain area's role in human language processing. Describe what you would expect to happen to the language ability of a patient with a lesion in this brain area. (10 points)

b) Wernicke's Area is another important brain region for human language processing. State this brain area's role in language processing. Describe what you would expect to happen to the language ability of a patient with a lesion in this brain area. (10 points)

c) Speculate what might happen in a monkey if its "Broca's Area" (left inferior frontal gyrus) were stimulated by electrodes. Provide clear reasoning for your speculation. (5 points)

**4. Methodology (25 points total)**

a) These 3 methodologies are commonly used in cognitive neuroscience studies: Event-Related Potentials (ERP), Magnetoencephalography (MEG), and functional magnetic resonance imaging (fMRI). For these methodologies, describe in detail how each of them obtains measures neural activity. For example, what is an ERP signal, how is it acquired from a participant in a research setting, and how does it relate to neural activity in the brain. (12 points)

b) For each of the above three methodologies, list their advantages and disadvantages as measures of brain activity, and compare them to each other by describing and giving examples of what sort of studies each method is most suitable for. (13 points)

**5. Research Proposal (25 points total)**

It has been suggested that language processing in humans predominantly relies on the left hemisphere brain. Propose a research study to evaluate this notion. In your proposal, specify what brain measurement approach you would use (e.g. fMRI, ERP, MEG etc.) and why. Be sure to describe your hypothesis, your experimental procedures with clear definitions of your task with the dependent and independent variables, your proposed analysis, your expected results, and possible limitations. (25 points)