Informatics 1 Cognitive Science
Mock Exam 2024/25

PART A
Please select exactly one answer from the following multiple choice questions.
Each question is worth 2 marks.

1. Consider the following context-free grammar for noun phrases (NPs):

   NP $\longrightarrow$ Det NX
   NX $\longrightarrow$ Adj NX
   NX $\longrightarrow$ N
   Adj $\longrightarrow$ blue
   Adj $\longrightarrow$ large
   Det $\longrightarrow$ the
   N $\longrightarrow$ dog

   How many NPs does the grammar generate?

   A. 2
   B. 4
   C. infinitely many
   D. 10

2. Suppose a Alice can accept or reject a bet. If she accepts the bet, the probability of winning is 0.1. Winning yields £100 and losing yields −£10. If she rejects the bet, she doesn't gain or lose anything.

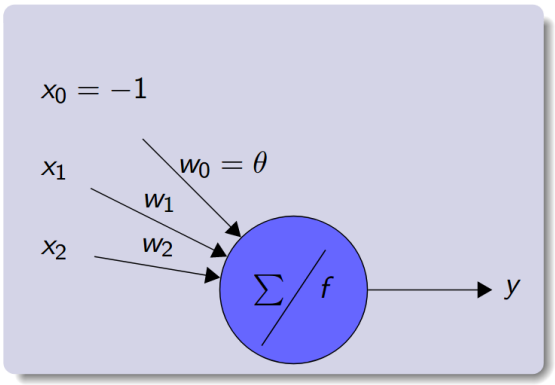
   Work out the expected utility if Alice accepts the bet. Assume that the utility of an outcome is equal to its monetary value.

   A. £1
   B. £10
   C. £0
   D. −£8

3. For the scenario in Question 2, assume that Alice overweights losses according to Prospect Theory, assuming wins have a weight of 1 and losses have a weight of 2. What is the expected utility now?

   A. £1
   B. £10
   C. £0
   D. −£8

4. Consider the following perceptron with $w_0 = 0.5$; $w_1 = -0.25$ and $w_2 = 0.6$. What is the output vector y for this perceptron? The answers are in the form (y_1, y_2, y_3, y_4). (Note that "???" indicates an unknown logical function.)



x_1	x_2	x_1 ??? x_2
0	0	y_1
0	1	y_2
1	0	y_3
1	1	y_4

A. $(0, 1, 0, 0)$
B. $(0, 0, 1, 0)$
C. $(0, 1, 0, 1)$
D. $(0, 0, 1, 1)$

5. In the course, we defined Bayes' rule as $P(\mathcal{H}|D) = \frac{P(D|\mathcal{H})P(\mathcal{H})}{P(D)}$, where $\mathcal{H}$ is a set of hypotheses, and D is evidence pertaining to these hypotheses. What happens to Bayes rule when there is no prior evidence available?

   A. $P(\mathcal{H}) = 0$
   B. $P(D)$ is a uniform distribution
   C. $P(\mathcal{H})$ is a uniform distribution.
   D. Bayes rule doesn't apply in this case.

6. Assume the following speech input:

   toabstractawayfromtheideaistoimprovetheideafurtherawayfromus

   Now assume that the listener segments this input into words as follows:

   toabstract away from theidea is toimprove theidea further away from us

   What is the description length of this segmentation?

   A. 10
   B. 11
   C. 46
   D. 56

7. Which of the following is a widely-accepted problem for the prototype theory of categorization?

   A. Category membership is based on similarity.
   B. It is difficult to combine existing prototypes to form composite categories (e.g., "pet fish").
   C. Category boundaries can be fuzzy (e.g., something can be both a bowl and a cup).
   D. None of the above.

8. How does the leaky integrate and fire (LIF) neuron model differ from the McCulloch-Pitts (MCP) neuron model?

A. The LIF model has a linear activation function while the MCP model has a step function.

B. The LIF model integrates input over time while the MCP model integrates input instantaneously.

C. The LIF model has a sigmoid activation function while the MCP model has a step function.

D. The LIF model sums inputs while the MCP model takes the maximum of the inputs.

9. How are synaptic weights modified by Hebbian plasticity?

A. The synaptic weight is increased when the activity of the pre- and postsynaptic neurons is correlated.

B. The synaptic weight is increased when the presynaptic neuron has high activity.

C. The synaptic weight is increased when the postsynaptic neuron has high activity.

D. The synaptic weight is increased when the activity of the pre- and postsynaptic neurons is uncorrelated.

10. What is the main advantage of functional MRI to record brain activity?

A. It has a high temporal resolution.

B. It has a high spatial resolution.

C. The nature of the fMRI signal is well understood.

D. It can record activity in the whole brain.

11. How does auto-associative memory differ from computer memory?

A. Auto-associative memory is content-addressable, not address-based.

B. Auto-associative memory is address-based, not content-addressable.

C. Auto-associative memory is faster to access than computer memory.

D. Auto-associative memory is faster to store than computer memory.

12. What is the role of the ventral visual pathway?

A. It is required for brightness perception.

B. It is required for object localisation.

C. It is required for object recognition.

D. It is required for perceiving movement.

13. How are long-term memories stored in the brain?

A. In a specific brain region dedicated to long-term memories.

B. In the strengths of synaptic connections between neurons.

C. Through the creation of new brain cells specifically for storing memories.

D. In reverberating activity of groups of connected neurons.

PART B

Please answer each of the following questions with a short answer. Each answer should be one or two sentences long.

Each question is worth 2 marks.

14. The *Words and Rules* models of the mental lexicon uses the listeme as a basic unit. Define what a listeme is.

15. The *Words and Rules* model generates the past tense form using rules for regular verbs, and using stored lexical entries for irregular verbs. How does the model avoid generating two past tense forms for irregular verbs?

16. Rumelhart and McClelland's model of past tense learning is conceived as an alternative the *Words and Rules* model. How is this model able to generate the past tense from of a new regular verbs without assuming any rules?

17. The weight update rule for perceptrons is $\Delta w_i = \eta(t - o)x_i$, where Δw_i is the update, η is the learning rate, t is the target output, o is the model output, and x_i in the input. Explain why the update rule includes the input x_i.

18. Explain the notion of *fast mapping* in word learning in children.

19. You are modeling visual word recognition as a Bayesian Update of the posterior distribution $P(w|v)$ of a word w given a visual input v. How would you quantify the change of the posterior from P_1 to P_2?

20. Explain the concept of *receptive field* for neurons in the retina, and what main types of neurons the retina has.

21. Explain which visual features are encoded by simple cells in the visual cortex.

22. Discuss why such features are useful for object recognition.

23. Explain the concept of *declarative memory*.

24. Describe the differences between unsupervised and supervised learning in the brain (you may give an example for each).

25. Describe Marr's three levels of analysis in cognitive science and give an example for each level.