PSY.BIO7 Ways of Studying the Brain: Scanning Techniques and EEG

Total Marks

AQA 7182 · Calculators not allowed · about 50 minutes

Name: _____ Date: ____ / ____ / _____

Answer all questions. Full-sentence answers required for extended questions and any question worth 3 marks or more. Allow about 50 minutes for the whole pack.

1 In the context of ways of studying the brain, outline what a post-mortem examination involves and name one type of analysis that can be done on brain tissue.

(Total for Question 1 is 2 marks)

2 Outline one strength of using post-mortem brain studies in investigating neurological disorders, as used in brain research.

(Total for Question 2 is 2 marks)

3 Outline one limitation of post-mortem studies when inferring causes of behaviour during life in brain research.

(Total for Question 3 is 2 marks)

4 Outline how functional magnetic resonance imaging (fMRI) is used to study brain activity, naming what fMRI measures as a proxy for neural activity.

(Total for Question 4 is 3 marks)

5 State one strength of fMRI when studying localisation of brain function in cognitive tasks.

(Total for Question 5 is 3 marks)

6 State one limitation of fMRI in studying brain function, referring to either temporal resolution or practical constraints in a research setting.

(Total for Question 6 is 3 marks)

7 Outline how an electroencephalogram (EEG) records brain activity and state what it measures directly from the scalp.

(Total for Question 7 is 3 marks)

8 State one strength of EEG compared with fMRI when investigating the time-course of cognitive processes in brain research.

(Total for Question 8 is 2 marks)

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9 State one limitation of EEG in localising the source of electrical activity within the brain, compared with structural or functional imaging.

(Total for Question 9 is 2 marks)

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10 Outline what an event-related potential (ERP) is in brain research and briefly explain how ERPs are obtained from EEG data.

(Total for Question 10 is 3 marks)

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11 Briefly state one use of EEG in research on sleep stages, as applicable to methods for studying the brain.

(Total for Question 11 is 2 marks)

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12 Complete the strengths and weaknesses comparison task: using fMRI and EEG as methods of studying the brain, give two strengths of fMRI and two weaknesses of EEG. Refer to resolution, invasiveness, or practicality as appropriate.

(Total for Question 12 is 6 marks)

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13 Compare functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) when used to study brain activity in cognitive neuroscience research. Describe how each technique measures brain activity and evaluate their relative strengths and limitations with reference to spatial and temporal resolution, invasiveness or practicality, and suitability for different research questions. Use examples where helpful.

Compare fMRI and EEG as methods for studying brain activity. In your answer, describe key features of each technique and evaluate their relative strengths and limitations for cognitive neuroscience research.

(Total for Question 13 is 8 marks)

Mark scheme · PSY.BIO7 Ways of Studying the Brain: Scanning Techniques and EEG

Question 1

- **B1** states that a post-mortem examination involves inspecting the brain after death to identify structural or tissue changes oe
- **B1** names a type of analysis such as structural examination for lesions, histology, or neurochemical assay (e.g. neurotransmitter levels) oe
- **Answer: A post-mortem examination inspects the brain after death to identify structural damage or tissue changes. Analyses can include structural inspection for lesions or histological and neurochemical assays to measure neurotransmitter levels.**

Question 2

- **B1** states a plausible strength, e.g. allows direct examination of brain structures and identification of physical damage or pathology oe
- **B1** explains why this is useful, e.g. can reveal anatomical or neurochemical abnormalities not detectable with non-invasive scans oe
- **Answer: Strength: allows direct examination of brain structures to identify lesions or neurochemical abnormalities, which can reveal physical causes of disorder that non-invasive methods might miss.**

Question 3

- **B1** identifies a limitation, e.g. observed damage may not have caused the behaviour recorded during life oe
- **B1** explains why this matters, e.g. lack of causal proof because changes could be the result of other factors or post-mortem processes oe
- **Answer: Limitation: damage seen after death cannot be shown definitively to have caused the behaviour during life, because other factors or post-mortem changes might account for the findings.**

Question 4

- **M1** states that fMRI measures changes in blood oxygenation and flow as an indirect marker of neural activity (the BOLD response) oe
- **A1** explains that participants complete tasks while the scanner records where blood oxygenation increases, indicating active brain regions oe
- **A1** mentions that the technique produces a series of 3D images showing localisation of activity over the brain oe
- **Answer: fMRI measures changes in blood oxygenation and flow, the BOLD response, as a proxy for neural activity. Participants perform tasks in the scanner while 3D images show which brain regions show increased blood oxygenation and are therefore active.**

Question 5

- **M1** identifies a strength, e.g. good spatial resolution allowing precise localisation of active brain regions oe
- **A1** explains why this is beneficial, e.g. helps map which cortical and subcortical areas are involved in specific cognitive tasks, useful for research and clinical planning oe
- **A1** may mention that results are non-invasive so suitable for healthy volunteers oe
- **Answer: Strength: fMRI has good spatial resolution, so it can localise activity to specific cortical or subcortical regions during cognitive tasks. This precise mapping is useful for research and for clinical planning, and it is non-invasive.**

Question 6

- **M1** identifies a limitation, e.g. poor temporal resolution compared with electrophysiological methods oe
- **A1** explains why this matters, e.g. the BOLD response is delayed and slow, so fMRI cannot track rapid neural processing in milliseconds oe
- **A1** or mentions practical limits such as high cost and the need for participants to remain still in a scanner oe
- **Answer: Limitation: fMRI has poor temporal resolution because the BOLD response is delayed and slow, so it cannot resolve neural events on the millisecond timescale. It is also expensive and requires participants to remain still inside the scanner.**

Question 7

- **M1** states that EEG records electrical activity produced by populations of neurons using electrodes placed on the scalp oe
- **A1** explains that the recorded signal is changes in voltage over time that reflect synchronous neuronal firing, especially of cortical pyramidal cells oe
- **A1** may mention that EEG produces wave patterns and can be displayed as continuous traces over time oe
- **Answer: EEG records electrical activity from the scalp using electrodes; it measures voltage changes over time that reflect synchronous firing of groups of neurons, producing characteristic wave patterns.**

Question 8

- **B1** identifies a strength, e.g. excellent temporal resolution, millisecond-level recording of brain activity oe
- **B1** briefly explains why this is useful, e.g. allows tracking of rapid cognitive events such as sensory processing in real time oe
- **Answer: Strength: EEG has excellent temporal resolution, with millisecond-level recordings, so it can track rapid cognitive events such as sensory processing in real time.**

Question 9

- **B1** identifies limitation, e.g. poor spatial resolution making it hard to pinpoint the exact source of recorded activity within the brain oe
- **B1** explains impact, e.g. signals are smeared by the skull and scalp, so EEG cannot localise deep brain activity precisely oe
- **Answer: Limitation: EEG has poor spatial resolution, because electrical signals are smeared by the skull and scalp, so it cannot precisely localise deep or closely spaced sources of activity.**

Question 10

- **M1** defines an ERP as a time-locked electrical response linked to a specific stimulus or event recorded from the scalp oe
- **A1** explains that ERPs are obtained by averaging EEG segments time-locked to repeated presentations of the same stimulus to isolate the stimulus-related signal from background noise oe
- **A1** may mention that particular ERP components are associated with cognitive processes such as attention or error detection oe
- **Answer: An ERP is a stimulus-locked electrical response recorded from the scalp. ERPs are obtained by averaging EEG epochs time-locked to repeated stimuli, which isolates the event-related signal from background EEG noise and reveals components linked to cognitive processes.**

Question 11

- **B1** states a use, e.g. EEG is used to identify different sleep stages by recording characteristic wave patterns such as slow-wave sleep and REM-associated patterns oe
- **B1** may mention that EEG helps classify the stages and transitions during sleep recording oe
- **Answer: EEG is used to identify different sleep stages by recording characteristic wave patterns, for example slow-wave activity in deep sleep and patterns associated with REM sleep, allowing classification of stages and transitions.**

Question 12

- **M1** gives one correct strength of fMRI such as high spatial resolution or non-invasive functional localisation oe
- **A1** gives a second correct strength of fMRI such as ability to produce 3D brain maps useful for research and clinical planning, or sensitivity to subcortical structures oe
- **M1** gives one correct weakness of EEG such as poor spatial resolution or inability to localise deep sources precisely oe
- **A1** explains that the skull and scalp smear signals, reducing localisation accuracy oe
- **M1** gives a second correct weakness of EEG such as susceptibility to artefacts from muscle or eye movements, or limited use for deep-brain activity oe
- **A1** briefly explains practical consequence, e.g. need for careful preprocessing and restricted experimental tasks to reduce artefacts oe
- **Answer: Two strengths of fMRI: 1) high spatial resolution allowing precise 3D localisation of active cortical and some subcortical regions; 2) non-invasive functional mapping that is useful for research and clinical planning. Two weaknesses of EEG: 1) poor spatial resolution so it cannot precisely localise deep or closely spaced sources because signals are smeared by the skull and scalp; 2) EEG is susceptible to artefacts from muscle and eye movements, requiring careful preprocessing and limiting some experimental setups.**

Question 13

- **Level 2** (5-8): Good knowledge and understanding of fMRI and EEG is shown, with clear description of how each technique measures brain activity. The evaluation is well developed and considers several relevant strengths and limitations, including spatial and temporal resolution, invasiveness and practical constraints, and applies these points to suitability for different research questions. Examples or applications are used and explained. Specialist terms are used accurately.
- **Level 1** (1-4): Basic knowledge of fMRI and EEG with limited description. Evaluation is present but superficial, mentioning one or two strengths or weaknesses without development. Limited application to research questions and few or no examples. Answer may be partly descriptive or list-like.
- **Level 0** (0): No creditworthy content.
- **Indicative content:**
  - AO1: fMRI measures changes in blood oxygenation and flow (BOLD response) as an indirect measure of neural activity and produces high-resolution 3D images of active brain regions.
  - AO1: EEG records electrical activity via electrodes on the scalp, measuring voltage changes over time produced by synchronous neuronal firing, producing waveforms with excellent temporal resolution.
  - AO3: fMRI strength - high spatial resolution allows precise localisation of cortical and some subcortical activity, useful for mapping brain areas involved in cognitive tasks and for clinical planning.
  - AO3: fMRI limitation - poor temporal resolution because the haemodynamic response is delayed and sluggish, so it cannot resolve rapid neural events; it is also expensive and requires participants to remain still, which restricts some designs.
  - AO3: EEG strength - excellent temporal resolution (millisecond-level) makes it ideal for studying the time-course of sensory and cognitive processing and for event-related potentials when time-locked responses are needed.
  - AO3: EEG limitation - poor spatial resolution and difficulty localising deep sources; susceptible to artefacts from muscle movements and eye blinks, requiring careful preprocessing.
  - AO3: Suitability - fMRI is well suited to questions about localisation and which brain structures are involved; EEG is better for questions about timing of processing or rapid neural dynamics and for paradigms like ERP that isolate cognitive components.
  - AO3: Combined approaches - using EEG and fMRI together or using ERPs derived from EEG can provide complementary information, offsetting weaknesses of each method; practical considerations and research aims determine the appropriate choice.