SL IB Psychology

Your notes

Techniques Used to Study the Brain

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Post Mortem Examinations

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Techniques used to Study the Brain: Post-Mortem Analysis

What is post-mortem analysis of the brain?

- **Post Mortem Analysis** of the brain involves examining the brain (usually in slices) to determine the cause of behaviour(s) or dysfunction experienced when the patient was alive
- This technique was used in the early days of biological psychology as there was no sophisticated technology available to look at a living brain
- This technique is used to investigate the **structure** of the brain, and from that to infer a correlation with behaviour e.g. why can patient X not recall any new information? Why is patient Y unable to speak in full sentences?
- Post-mortem analysis may still be used today if there are no alternatives available e.g. **Alzheimer's** disease can only really be determined by conducting a post-mortem analysis

Which studies use post-mortem analysis?

- Post-mortem analysis of the brain was used alongside other techniques to investigate the damage done to **HM's** brain **(Corkin, 1997)** and helped to determine the link between the **hippocampus** and the formation of new memories
- A year after HM died his preserved brain was sent to the University of California where it was sliced into 2,401 sections, which were placed on slides and scanned, as a permanent neurological research resource
- **Paul Broca's (1861)** post-mortem analysis of his patient 'Tan' was a breakthrough in terms of locating the language area of the brain in the **left hemisphere**

Both of these studies are available as separate Key Studies – just navigate the Brain and Behaviour section of this topic to find them.

Your notes

Having more than one brain just seems greedy…

Exam Tip

If you use post-mortem analysis as a technique used to study the brain in an exam answer, remember that this is not a *brain-imaging* or *brain-scanning* technique as there is no way of producing scans or images from this type of technique. Post-mortem analysis provides slices of brain or brain matter which can then be further analysed using a range of techniques which may involve technology but the technique itself is definitely old-school.

What are the strengths and limitations of post-mortem analysis of the brain?

Strengths:

- It enables researchers to study a brain without inflicting any harm on the living person
- It can help clinicians to confirm a diagnosis e.g. the patient was suspected of having Alzheimer's but this can only be decided conclusively using post-mortem methods

Limitations:

- It is not possible to compare what is measured post-mortem to a living brain
- It is not possible to study brain **function** using post-mortem analysis

Your notes

Exam Tip

Remember that techniques used to study the brain are *not* research methods. Research methods include lab **experiments, questionnaires, observations** etc. Techniques used to study the brain are used as *part of* a research method e.g. the study of HM was a **case study** which involved a range of methods and techniques.

Two Key Studies using Post-Mortem Analysis: The case of HM (Corkin 1997) & The Case of Tan (Broca 1861)

Your notes

Exam Tip

You can use BOTH studies in a question on Localisation of Function

Key Study 1: The case of HM (Milner 1968, Corkin 1997)

Your notes

Aim: To investigate memory loss in a brain-damaged patient known as HM via examination of his brain post-mortem

Participant: The patient known as 'HM', (Henry Molaison) had been run over by a bicycle at the age of nine which resulted in him experiencing epileptic fits. These became so severe that at the age of 27 he underwent a bilateral medial temporal lobe re-section which involved the removal of about two thirds of his hippocampus. HM's epilepsy improved but he began to suffer extreme anterograde amnesia and partial retrograde amnesia: he completely lost the ability to form new memories while long-term memories from the past remained fairly intact

Procedure: HM was initially studied by Brenda Milner, a doctoral student who visited HM frequently, administering a range of tests and measures including psychiatric tests such as personality and mood tests, depression questionnaires, and interviews with psychiatrists. His scores did not indicate depression, anxiety or psychosis and he communicated a good awareness of his condition (i.e. he did not 'forget' that he was suffering from anterograde amnesia). He completed a standard IQ test on which his score was normal, however his scores on the Wechsler Memory Scale test demonstrated his severe memory impairment. Milner noted that HM frequently forgot what had happened that day, thought he was younger than his actual age, forgot the names of people he had just met and commented that every day felt as if he was just waking up from a dream. Milner studied him (and later, Corkin) for over 50 years until his death at the age of 82

Results: The key finding from the study of HM is that memory is not simply part and parcel of a collection of **cognitive** functions which reside in the **cortex,** rather it is a distinct function which is localised to the **temporal lobe**, specifically the **hippocampus**. Post-mortem analysis of HM's brain helped to confirm these findings

Conclusion: Hippocampal damage may be linked to long-term anterograde amnesia

Evaluation of the case of HM (Milner 1958, Corkin 1997)

Strengths

- This case study employed both qualitative and quantitative methods, generating both reliable and rich data
- Being able to study HM's brain post-mortem allowed the researchers to **validate** the theory that the hippocampus is strongly implicated in memory formation

Limitations

- One possible confounding variable could be that HM's brain was already damaged due to his epilepsy which would decrease the validity of the findings
- Working closely with one participant for decades could mean that researcher bias may have interfered with Milner's objectivity

Your notes

Key Study 2: The case of Tan (Broca 1861)

Aim: To investigate speech impairment in one patient.

Participant: The patient known as 'Tan' was being cared for by a French doctor, Paul Broca. The patient was given the name of 'Tan' as this was the only word that he could say even though his mouth, tongue and vocal cords were normal. He could understand what was said to him, but he could not reply in any way that was articulate.

Procedure: Broca made observations of Tan's behaviour and speech over a long period of time. After Tan's death, Broca conducted a post-mortem analysis of his brain.

Results: Broca found that Tan had a catastrophic **lesion** in his **left frontal lobe**.

Conclusion: Language – specifically speech production - can be localised to the left frontal lobe in a region now known as Broca's area. If damage occurs in this area it results in Broca's **aphasia** i.e. the inability to produce coherent speech.

Evaluation of Broca (1861)

Strengths

- The longitudinal nature of this study (and similarly in the case of HM) means that a full, in-depth investigation into the individual and their condition was possible
- Tan's case highlighted important new insight into the brain and its link to language and speech production

Limitations

- This is extremely dated research; a modern researcher would be able to use a range of brain-imaging techniques to isolate the brain region involved in the condition
- There may have been other explanations for Tan's speech impairment which were not explored at the time

Your notes

MRI Brain Scan

Techniques used to Study the Brain: MRI

What is MRI scanning?

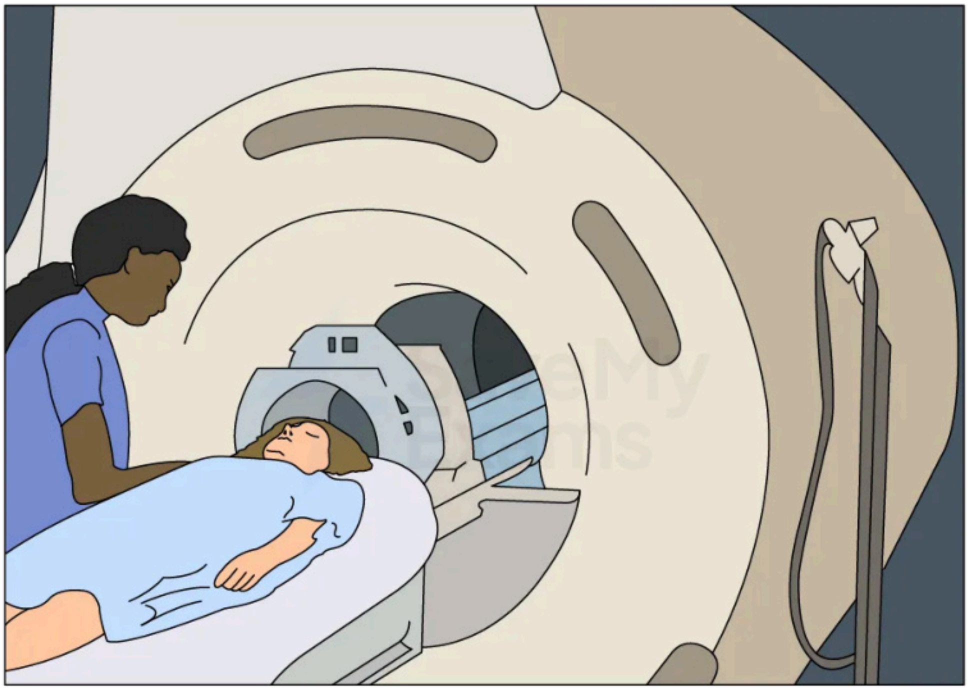
- **Magnetic Resonance Imaging (MRI)** uses a large magnet and pulses of radio waves to scan the brain, producing images of brain **structures**
- MRI produces a picture of the inside of the brain or body by measuring **hydrogen nuclei** in the area that is being scanned
- The patient being scanned is placed inside a 'doughnut'-type tube and they are asked to keep very still as any movement may affect the precision of the measurement
- The scanner makes a loud, banging noise while it is scanning which may be distressing for the patient
- Patients are asked to remove all metal objects from their person so MRI scanning would not be suitable for anyone with metal implants in their body
- MRI scans can show areas the size of brain structures, the volume of **grey matter** within those structures, brain damage, bleeding and tumours

Which studies use MRI?

- MRI was used to scan the brains of taxi drivers **(Maguire 2000)** in order to determine a correlation between spatial navigation and hippocampal grey matter
- **Luby et al. (2013)** used MRI to assess the affects of poverty on a child's developing brain

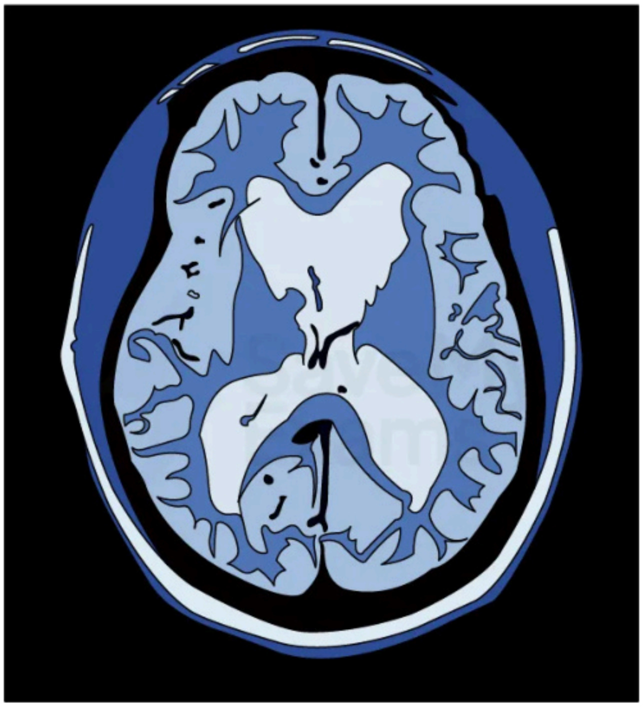
Both of these studies are available as separate Key Studies – just navigate the Brain and Behaviour section of this topic to find them.

Your notes



A MACHINE SUCH AS THIS IS USED FOR MRI, FMRI AND PET SCANNING

Your notes



AN MRI SCAN

Exam Tip

Remember that MRI scans only measure *structure*, not *function*.

What are the strengths and limitations of MRI?

Strengths:

- MRI enables researchers to pinpoint specific brain structures which may be damaged or have increased grey matter to identify the link between brain and behaviour
- MRI is less invasive than techniques such as PET as it does not require the use of radiation

Limitations:

- MRI scanners are prone to disturbance caused by noise, temperature and human error in calibration which means that they are not always reliable
- MRI scanners would not be suitable for someone who suffers from claustrophobia due to the enclosed environment of the machine

Your notes

Exam Tip

MRI uses **objective** measures (the use of a machine, the production of the scan) but they are still prone to possible **bias** on the part of the researcher e.g. in the interpretation of the resulting scan images.

Worked example

Explain the use of one technique used to study the brain. [9]

Here is an example of a paragraph which could be used to explain what is involved in the procedure of MRI scanning. Note that the language is clear, concise and uses key terminology:

Magnetic Resonance Imaging Scan (MRI) uses a scanning machine which contains two powerful magnets, pulsing radio waves and a computer to produce images of brain structures. The two magnets in MRI attract protons in the organism. The first magnet aligns water molecules in the body, and the second magnet is turned on and off in a series of quick pulses, causing hydrogen atoms to switch back to their relaxed state. This procedure as a whole enables images of brain structures to be taken and then analysed.

Two Key Studies using MRI: Maguire (2000) & Luby et al. (2013)

Your notes

Exam Tip

You can use BOTH studies in a question on NEUROPLASTICITY. Maguire (2000) can also be used to answer a question on LOCALISATION OF FUNCTION

Key Study 1: Maguire (2000)

Your notes

Aim: To investigate the use of **MRI brain-imaging technology** to investigate **spatial navigation** in London black cab taxi drivers

Participants: 16 healthy, right-handed male London black cab taxi drivers who had passed 'The Knowledge', a test of spatial navigation, aged 32-62 years with a mean age of 44 years. They had all been taxi drivers for at least 18 months, with the highest number of years as a taxi driver at 42 years

Procedure: The participants were placed in an MRI scanner and their brains were scanned. The MRI measured the volume of **grey matter** in the **hippocampus** of each participant, and this was then compared to pre-existing scans of 50 healthy, right-handed males (the **control group**). Grey matter was measured using **voxel-based morphemetry** (VBM) which focuses on the density of grey matter and **pixel counting**

Results: The **posterior hippocampi** of the taxi drivers showed a greater volume of grey matter than that of the controls, who had increased grey matter in their **anterior hippocampi** compared to the taxi drivers. Maguire also carried out a **correlational analysis** which showed a positive correlation between volume of posterior hippocampal grey matter and length of time spent as a taxi driver

Conclusion: The posterior hippocampus may be linked to spatial navigation skills

Evaluation of Maguire (2000)

Strengths

- The study used a highly controlled clinical method of obtaining **objective** data which could then be easily compared and analysed
- The study used a researcher who was **blind** to the conditions to count the pixels on the MRI images which increases the **internal validity** of the study

Limitations

- A correlation cannot show cause-and-effect so it is impossible to know whether the taxi drivers already had naturally high levels of hippocampal grey matter
- The results are only **generalisable** to male, right-handed London taxi drivers

Key terms:

- **Spatial navigation**
- **Posterior hippocampus**
- **Voxel-based morphometry**

Key Study 2: Luby et al. (2013)

Your notes

Aim: TTo investigate whether poverty experienced in childhood is shown in delayed brain development using MRI scanning

Participants: Children who were already enrolled on a 10-year **longitudinal** study of Preschool Depression: 145 right-handed children from the USA. The children were categorised as living in poverty

Procedure: The children had undergone regular testing: once a year (over 3-6 years) which consisted of a series of tests aimed to measure their cognitive, emotional and social skills. The researchers also collected data on how close the children were to their caregivers as well as incidences of any negative and stressful events in their lives. Each child then had two MRI scans in which the whole brain was scanned (session 1) or just the **hippocampus** and the **amygdala** (session 2)

Results: Both the hippocampus and the amygdala showed less **white** and **grey matter** in the MRI scans. However, if the child had experienced positive care from adults there was a less negative effect on the hippocampus. Difficult and stressful life events only affected the left hippocampus

Conclusion: Poverty does appear to have a negative effect on brain development in childhood, but this can be reduced by the quality of caregiving the child experiences

Evaluation of Luby et al. (2013)

Strengths

- The researchers were able to check the behavioural, cognitive, and social measures against the MRI results which increases the **internal validity** of the study
- The study's **longitudinal** design means that real changes and comparisons across time could be made, as seen in the differences in the MRI scans

Limitations

- The MRI scans may have picked up differences in the brains of the children which were not the result of poverty but of other, unknown factors
- The sample is difficult to **generalise** from as it only represents pre-school children living in poverty who exhibit symptoms of depression so it cannot explain how poverty may affect non-depressed children

Key terms:

- **Hippocampus**
- **Amygdala**
- **Mediating factors**

FMRI & PET Scans

Your notes

Techniques used to Study the Brain: fMRI and PET

What is fMRI?

- **Functional Magnetic Resonance Imaging (fMRI)** measures **oxygenated blood flow** in the brain i.e. brain activity
- Oxygenated blood has a different **resonance** than deoxygenated blood: more active areas of the brain receive more oxygenated blood
- A computer transforms the information into a brightly coloured **3D image** which is mapped using **voxels** (each voxel = thousands of **neurons**)

What is PET?

- **Positron Emission Tomography (PET)** uses a radioactive tracer to measure glucose metabolism of specific regions in the brain
- The tracer used in PET attaches to glucose molecules and – due to its bright intensity- can show which areas of the brain are active during a task
- If cells require more energy they will burn more glucose and this is what is shown in the scan

Which studies use PET?

- fMRI was used by **Fisher et al. (2003)** in her study of the link between romantic love and dopaminergic activity in the brain
- PET was used by **Raine et al. (1997)** to investigate the role of the **prefrontal cortex** in the brains of impulsive murderers

Both of these studies are available as separate Key Studies – just navigate the Brain and Behaviour section of this topic to find them.

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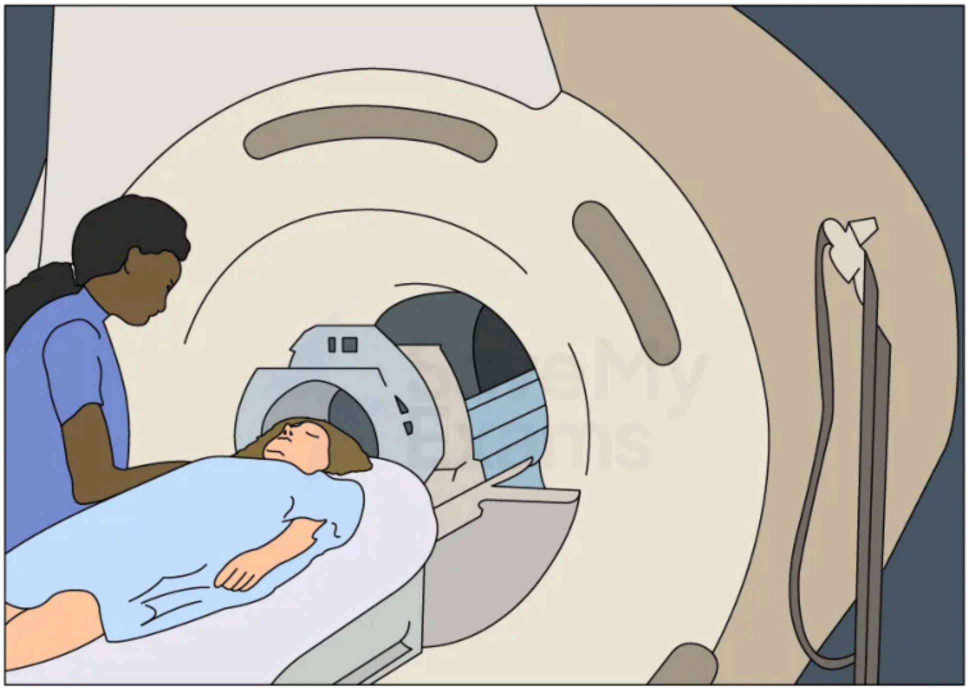
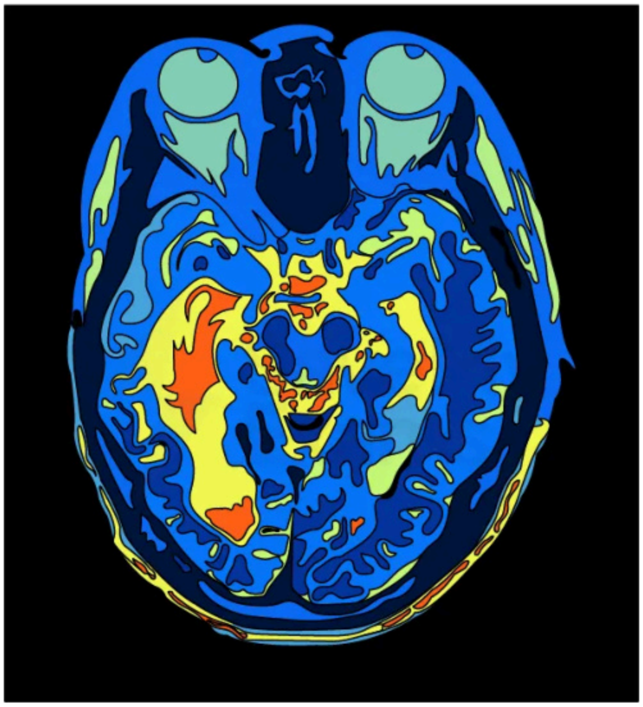


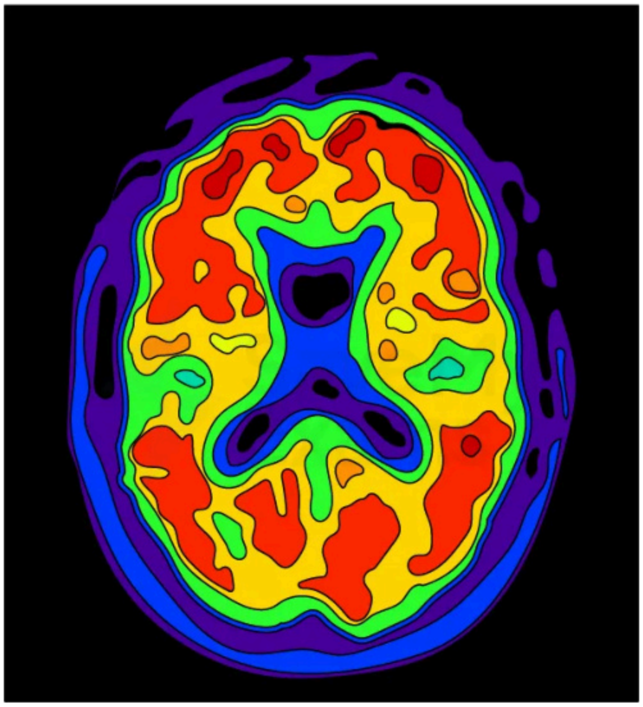
A MACHINE SUCH AS THIS IS USED FOR MRI, FMRI AND PET SCANNING

Your notes



AN fMRI SCAN

Your notes



A PET SCAN

Exam Tip

fMRI and PET scans are interpreted according to the intensity and brightness of the image: the areas in 'fiery' colours such as red, orange and yellow indicate the highest levels of activity (with red showing the most activity) while the 'cooler' colours such as blue, green and black indicate very little or no activity.

What are the strengths and limitations of fMRI?

Strengths:

- It enables researchers to measure oxygenated blood in specific brain regions which can inform them of brain activity linked to cognitive processes such as emotion
- It does not use radiation (unlike PET) so it is a non-invasive procedure

Limitations:

- fMRI is slow, having a 5-second delay between brain activity and measurement and so it may miss some important information
- It is an expensive procedure (as is MRI) so its use is limited and may vary according to a hospital or research institute's budget

Your notes

What are the strengths and limitations of PET?

- Strength: It is more sensitive than other scanning techniques and can highlight **abnormalities** and illness more successfully
- PET scans are not affected by small movements which makes it an easier procedure for the patient to endure

Limitations:

- Using a radioactive tracer involves some risk to the patient
- The images produced by a PET scan are not as clear as those produced by fMRI

Exam Tip

You might want to think about including some critical thinking on culture into a 22-mark question on the use of brain-imaging technology such as fMRI and PET. It may be that some collectivist cultures do not agree with modern technologies as a way of diagnosing illness (particularly mental illness) which would mean that the use of these techniques might be problematic in some cultures.

Two Key Studies using fMRI & PET Scans: Fisher et al. (2003) & Raine et al. (1997)

Your notes

Key Study 1: Fisher et al. (2005)

Aim: To investigate the **brain systems** involved in early-stage intense romantic love**.**

Participants: 10 females and 7 males from New York State University (**self-selecting** sample), aged from 18-26 years old (mean age 20). All participants reported being 'in love' (a range of 1-17 months; mean = 7 months).

Procedure: Participants were placed in an fMRI scanner and shown a photograph of their loved one followed by a distraction task and then a 'neutral' photograph of an acquaintance with whom they had a non-emotional relationship.

Results: The researchers found that when the participants viewed the photograph of their loved one specific areas of the brain were active: the right **ventral tegmental** areas and the right **caudate nucleus**. Both of these areas are strongly associated with **dopamine** activation (a **neurotransmitter** which induces a feeling of reward and motivation in people).

Conclusion: The results suggest that people in the early, intense stages of romantic love access the areas of the brain most associated with motivation and reward, giving rise to the idea that people become 'addicted to love'. **Dopaminergic reward pathways** may contribute to the 'general arousal' component of romantic love, making it a **biological** process rather than a **cognitive** one.

Evaluation of Fisher et al. (2005)

Strengths

- The use of a **standardised procedure** means that the study is **replicable**, which increases its reliability
- The use of fMRI means that the study was able to support to the idea that human beings may have evolved a brain system which ensures that they become addicted to love which increases the study's validity.

Limitations

- The small sample size of 17 participants means that the results are not very meaningful and may not be **robust** in terms of **statistical analysis**.
- The idea that romantic love can be measured via fMRI is overly **reductionist**: there may be a range of other factors involved, such as compatible personalities, shared ideals, cultural influences.

Your notes

Key Study 2: Raine et al. (1997)

Aim: To investigate whether there are any differences in the brains of impulsive murderers compared to non-murderers.

Participants: 41 murderers (39 males and 2 females) who had been tried in California for either murder or manslaughter. They had all pleaded NGRI – not guilty by reason of insanity (6 had **schizophrenia**; 23 had head injuries or organic brain damage; 3 had a history of **psychoactive** drug abuse; 2 had depression; 2 had epilepsy). They had a mean age of 34.3.

The study used a **matched pairs** design consisting of a **control group** of non-murderers (matched on age and gender, around the same age, with 6 schizophrenic individuals in the group).

Procedure: Each participant was injected with a radioactive tracer. 30 minutes after the injection, the participant was placed in a PET scanner. The participants were asked to complete a series of simple **cognitive** tasks e.g. recognising a 0 while the PET scan took place. 10 pictures were recorded which provided details in relation to differences in **glucose metabolism** in specific areas of the brain.

Results: The impulsive murderer group showed less activity in the **prefrontal cortex** (PFC), an area of the brain which has been linked to impulse-control and the ability to plan ahead. The murderer group also showed **asymmetrical** activity in the **amygdala** (more activity on the right side than the left) which means they were more likely to experience a lack of emotional control, a lack of fear and the inability to learn from past mistakes.

Conclusion: Brain dysfunction (seen via PET scan as a lack of activity in the PFC and asymmetry of the amygdala) may mean that someone is more prone to violent outbursts.

Evaluation of Raine et al. (1997)

Strengths

- The use of a matched pairs design means that **individual differences** could to some extent be **controlled** for
- This use of a **purposive** sample of NGRI murderers increases the validity of the study as the participants had all experienced a lack of control which led to violent behaviour thus they may all share similar features of brain function

Limitations

- The results of this study may lead to a **deterministic** bias against offenders guilty of impulsive murder i.e. that they have no **autonomy** or **free will** and are at the mercy of their biological functions
- This is an example of a **snapshot** design: it cannot tell us anything about behaviour across time

Exam Tip

You can use Fisher et al. (2005) in a question on NEUROTRANSMITTERS AND THEIR EFFECT ON BEHAVIOUR.

Your notes

Worked example

Discuss techniques used to study the brain in relation to behaviour. [22]

What follows are two paragraphs evaluating Raine et al. (1997). Note the way in which the response expands on and develops the points put forward, the use of terminology and the focus on the question:

It might be inferred from Raine's findings that NGRI murderers do not use their PFC to interpret and respond to non-emotional stimuli, reacting instead in an emotional manner which could indicate unusual amygdala activity. If the NGRI murderers had been using their amygdala rather than their PFC to interpret behaviour then it is possible that this might have resulted in low impulse control and thus, violent murder. The external validity of such a finding is, however, debatable; it is not a straightforward path from a result observed in a PET scan to behaviour enacted in real settings. There is no real evidence to show conclusively that the NGRI murderers' crimes came from the same biological place; there could be a huge range of other influences that produced the behaviour e.g. alcohol abuse, situational pressure, upbringing in a violent home etc. In this way, a PET scan is limited as it can only tell one part of a complex story; the role of the PFC may in fact have had little to do with the NGRI's crimes, but it is interesting nonetheless to note that all of the NGRI sample shared this same lack of activity in the PFC.

One of the main strengths of Raine (1997) is that it used a large sample in terms of PET scan research, the largest up to that point in time. The effect size reported by Raine was also quite robust, being 0.55, showing that there may well indeed be a biological correlate (low PFC activity) that is linked to impulsive, violent behaviour (impulsive murder). Without the use of a PET scan, it would have been impossible for Raine to ascertain such results and to reach a solid conclusion. The findings of this study were really the first in the field of criminal behaviour research to link PFC function with criminality. Raine's findings might be used in clinical and forensic settings to inform rehabilitation programmes and to go some way towards preventing crimes from taking place, although this is a more problematic prospect as it requires knowledge of each criminal's brain activity which can only be achieved via expensive scanning methods.