

**IB DIPLOMA
PSYCHOLOGY**

tutor2u 

CORE COMPANION

Biological Approach



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IB DIPLOMA PSYCHOLOGY CORE COMPANION: BIOLOGICAL APPROACH

This IB Diploma Psychology Core Companion has been organised to support teaching and learning by taking a systematic structure, based on the specifications in the IB Diploma Psychology guide (first exams May 2019). The biological approach topics and associated content are laid out to facilitate understanding of the correlation between brain processes and human behaviour: each topic is explained and the theories are supported by at least one study, which is evaluated. Critical thinking is applied throughout, and the arguments made in classic studies are extended by the use of recent examples. Biological psychology cannot be used on its own to explain human behaviour, so this chapter should be used in conjunction with the sociocultural and cognitive approaches for a holistic explanation.

Topics are:

- Part 1: The Brain and Behaviour
- Part 2: Hormones and Behaviour
- Part 3: Genetics and Behaviour
- Part 4 (HL extension only): The Role of Animal Research in Understanding Human Behaviour

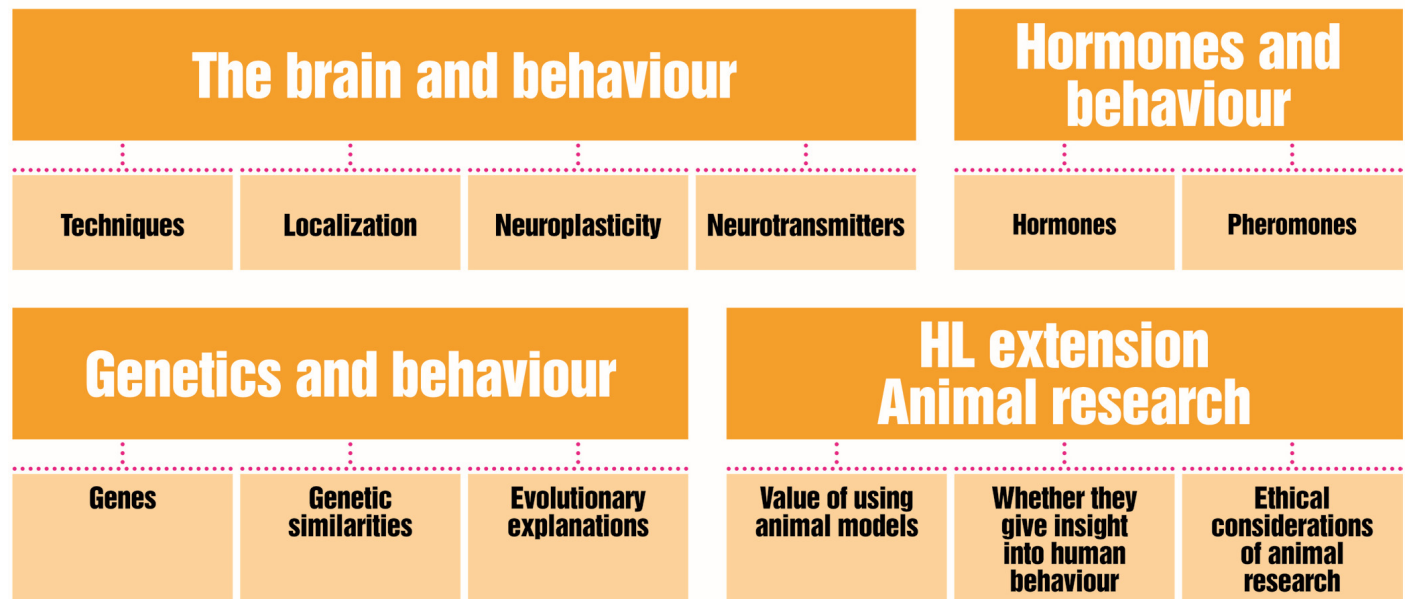
Each topic is broken down into its constituent content sections, following the new course specifications, and at the end of each content section there are a few examples of possible exam-style questions.

In line with the underlying philosophy of the biological approach, that there is a direct relationship between the brain and behaviour, we examine methods used to explore brain/behaviour correlations, analyse explanations of genetic heritability, and investigate the role of animal research in explaining human behaviour (HL only). Alternative arguments are explored where appropriate.

Approaches to research (methods) and ethical considerations are woven through the text, and also summarised at the end of each section, using the studies from the text as examples. While this is not a biological text, it is biological psychology, with some challenging terminology. Any complex concepts and vocabulary are explained as soon as they are used, and there is a useful key terms table and list of references at the end of the chapter.

BIOLOGICAL APPROACH: INTRODUCTION

The biological approach is one of the three core approaches in IB Diploma Psychology (the other two are the cognitive approach and the sociocultural approach). It is concerned with interactions between the brain and behaviour, and methods of studying these.



The biological approach to psychological research relies on three key assumptions:

- The structure of and activity within our brains and bodies, through the **nervous system** (via **neurotransmitters**) and the **endocrine system** (via **hormones**), are directly correlated with our cognition, emotions and behaviour. (These structures can be changed genetically, which gives us the link to the assumption below.)
- The **heritability of behaviour**, which means that we don't only inherit our hair and eye colour from our parents and grandparents, but also our attitudes and behaviours, though genetic transmission. This is related to the previous assumption.
- Animal research may inform our understanding of human behaviour, because many animals have brains and nervous systems that are similar to humans. Therefore, it is legitimate and useful to use animals in research to understand human behaviour.

PART 1: THE BRAIN AND BEHAVIOUR

WHAT YOU NEED TO KNOW
Part 1A: Techniques used to study the brain in relation to behaviour – How and why are certain techniques used to study the brain?
Part 1B: Localization – To what extent is there a relationship between certain behaviours and activity in corresponding areas of the brain?
Part 1C: Neuroplasticity – How does the brain change in response to learning and the environment?
Part 1D: Neurotransmitters and their effect on behaviour – How does neurotransmission affect human behaviour?

PART 1A: TECHNIQUES USED TO STUDY THE BRAIN IN RELATION TO BEHAVIOUR

Key Question: How and why are certain techniques used to study the brain?

If we are to investigate correlations between the brain and behaviour, and in some cases set up controlled experiments to try to isolate a cause and effect relationship, then we need to be able to see inside the brain and study the structure and processes. There are many different techniques used in psychological research. They generally fall into two groups: those that look at the brain structure while the person is at rest and those that investigate brain processes while the person performs some activity.

Techniques Investigating Brain Structure

These techniques are useful for identifying brain damage after accidents or strokes, and problems such as tumours or aneurysms (bulges in blood vessels).

Brain Autopsy

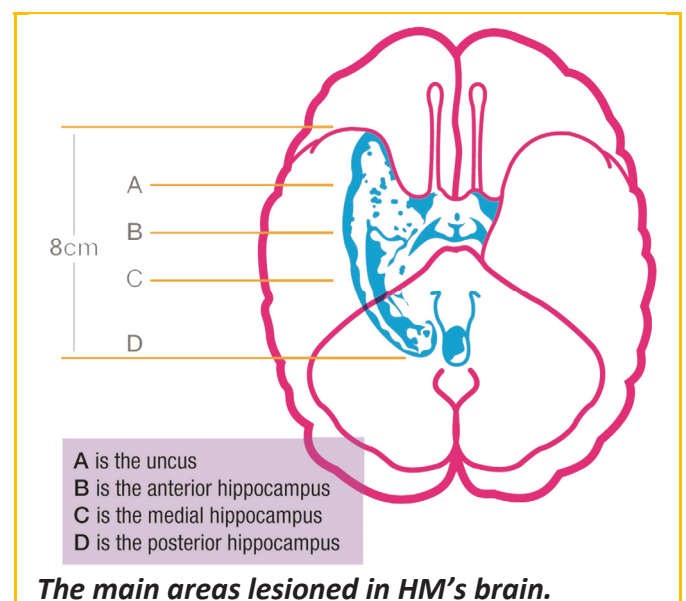
An early technique to look at the structure of the brain, and from that to infer a correlation with behaviour, is brain **autopsy** (observation of the structures of a dead brain). It is used on people who while alive demonstrated some behavioural or cognitive problem. Although it is tempting to say that it has been replaced by modern brain imaging, there are still some disorders, such as Alzheimer's disease, that cannot be *definitely* diagnosed until a brain autopsy has been performed. Scans can show the death of brain matter, but not identify the exact cause, although a probable diagnosis is usually given.

Henry Molaison (known anonymously as HM throughout his life) was a young man with incurable and debilitating epilepsy for which he received surgery in 1953. This involved the surgeon, William Beecher Scoville, removing 5-6 cms of brain tissue from each **hippocampus** and some surrounding **temporal lobe** tissue. Suzanne Corkin, a neuroscientist at Massachusetts Institute of Technology (MIT), who had been studying Henry for nearly fifty years, scanned his brain again just after his death from respiratory failure in 2008, at the age of 82, to establish finally what the damage was after all these years following his surgery (Corkin *et al.*, 1997; Ogden, 2012).

Henry donated his brain to MIT and a year after he died, his preserved brain was sent to a University of California lab in San Diego, where it was frozen and sliced into 2,401 fine sections, which were placed on slides and scanned, as a permanent neurological research resource available online to neuroscientists worldwide. The preparation and slicing is described in great detail in Annese *et al.* (2014).

Evaluation of Brain Autopsy

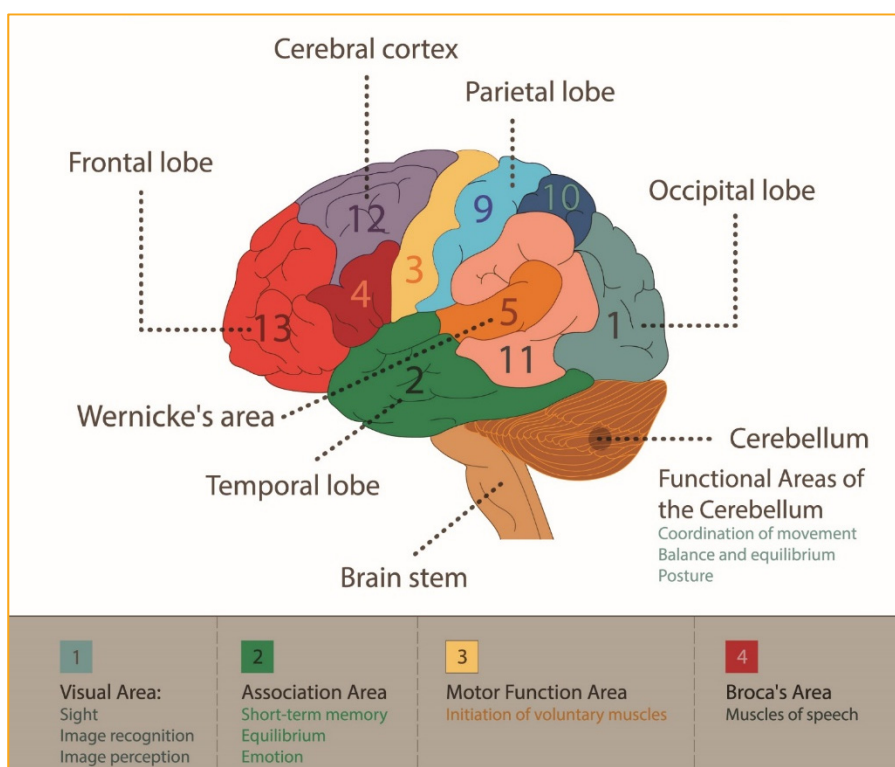
- **Strengths:** It is possible to be as thorough and detailed as the researcher wishes, without fear of damaging a living person.
- It is a useful method for confirming diagnosis post-mortem, and this confirmation, once replicated enough times, can be generalised to people suffering the same symptoms in their lifetime and possible treatment can be initiated.



- **Limitations:** Medical expertise and qualifications are needed, and many people do not donate their brains for research, so there is a very limited supply. Moreover, there is even less likelihood of healthy brains being donated, and therefore there is a lack of controlled comparison in some cases. Tomas Revesz, Professor of Neuropathology at University College, London, points out: 'The brain is so complex that there is no ideal simulated alternative for essential research into neuro-degenerative diseases. And, unlike other organs, the brain cannot be fully investigated when a patient is alive without the potential for fatal damage' (reported in *The Independent* newspaper, 2009).
- Only inference is possible: the researcher infers from the damage visible in the brain what caused the behaviour noted before death. However, brain autopsy, of course, is conducted on dead brains, and this is a confounding variable: the researcher cannot be sure that any damage they observe is identical to what would have been observed in the live brain, and of course no direct correlation with behaviour can be observed.
- It is not possible to study brain processes (as there are none), only structure.
- Of course, the brain autopsy is too late to suggest treatment for the patient, though it can be used to suggest treatment for others with similar problems.

Brain Surgery

Exploratory brain surgery is still used, especially in cases of brain tumours, where the exact boundaries of the growth cannot always be determined by brain imaging scans, and where the patient is so ill that any damage done by the surgery can be justified in the ultimate fight to save life.



People suffering from serious epilepsy often also experience social and psychiatric problems. For example, they often complain of social isolation, lower levels of employment and have difficulties because of their inability to drive. Similarly, and clearly not unrelated to their social difficulties, they also sometimes suffer from mood and anxiety disorders and higher rates of depression (Sperli *et al.*, 2009; Jacoby *et al.*, 2009). This leads many to accept quite invasive surgery to investigate and hopefully cure their epilepsy. Interestingly, removal of tissue from just *one* hippocampus and temporal lobe area is still a recognised procedure for treating

intractable epilepsy that does not respond to medicines. A recent meta-analysis of outcomes after this type of surgery suggest that between 53 and 84% of patients experience freedom from seizures for at least a year after temporal lobe surgery, and a much-improved quality of life (Spencer and Huh, 2008). Griessenauer *et al.* (2015) report an average rate of success of 73.4% with **hemispherectomy**, disconnecting the cortex of one side of the brain from the other, in children who have non-temporal lobe epilepsy. So, we can see, that although more modern brain imaging techniques may be useful for

identifying problems and studying the brain, sometimes autopsy and surgery can give further insight, and the fact that removal of brain tissue from the temporal lobe area, or a more drastic hemispherectomy, can relieve epilepsy suggests a direct correlation between brain and behaviour. Brain **lesion** studies have informed our understanding of which brain regions can be removed with minimal consequences for the patient.

Evaluation of Brain Surgery

- **Strength:** Especially for intractable epilepsy, brain lesioning or hemispherectomy has been shown to be successful in a majority of cases; it decreases the severity and number of seizures and improves the quality of patients' lives.
- It can, in combination with brain imaging techniques, give otherwise unknowable information about the physical limits of tumours, blood clots and bleeding deep in the brain, and allow for the removal of such if possible.
- **Limitations:** It is a highly invasive procedure that is often risky to the patient's health. A cost-benefit analysis is important before any exploratory brain surgery, as there is a real risk of worsening a condition and even leading to the patient's death.
- Not a procedure for learning about human behaviour in general, as it is individually targeted and the results, while they may be published in medical journals, are usually not generalised.

Computerised Tomography (CT)

This is the more recent name for what used to be called **Computerised Axial Tomography (CAT)**. It is a scanning method that uses 2D x-ray images of a 'slice' of the brain, which can then be used to construct 3D detailed pictures of the brain. It can see tissues within an organ, and sometimes a patient is asked to drink a barium meal containing a contrast dye, if an organ such as the stomach or the oesophagus is being scanned. Like the MRI (below) it is useful for identifying bleeding in the brain, swollen blood vessels or brain tumours. It can safely be used on patients with metal implants, and is more useful than MRI for detecting skull fractures and bleeding in the brain.

Evaluation of CT

- **Strengths:** CT scans can produce images regarding blood vessels, soft tissues and bones simultaneously. They give extremely detailed data in a quick time (usually around five minutes) regarding bleeding in the brain or fractures to the skull after accidents.
- They are faster and cheaper than MRI scans (see below), and most large hospitals have a CT scanner available in their emergency area.
- They do not use magnetism, and so can be used on people with heart pacemakers and metal implants.
- **Limitations:** CT scanning may increase cancer risk (as a result of radiation), and often involves injection of intravenous agents, which can occasionally trigger unwanted side effects, adverse long-term effects, and potential allergic reactions. It is not used on pregnant women for this reason, unless the benefits (of identifying a potentially deadly blood clot on the brain, for example) outweigh the risks.
- While cheaper than MRI scanning, the cost of a CT scan is still not negligible, with a collection of health providers in the USA quoting anything from \$500 to over \$2,000 for a head scan. (Data from a search of online price quotes given since 2012.)

Magnetic Resonance Imaging (MRI)

An MRI scanner uses **magnetic resonance imaging** (magnets and radio waves) to produce a picture of the structure of the brain by measuring the hydrogen nuclei in the body. The image can be manipulated to focus on whichever area is of interest. Magnetic resonance imaging is the use of a magnetic field combined with pulses of radio wave energy to take the pictures. The person is usually placed within a tube-like machine and asked to keep still. MRI brain scans can show tumours, bleeding in the brain, nerve injury, and other problems, such as damage caused by a stroke. They can also show changes in the size of particular brain structures, in response to learning or environment, as they did in the study below. While an MRI can be used to investigate changes in the grey matter (neurons without the white **myelin** sheath) nearer the surface of the brain, a newer form of MRI scanning, **Diffusion Tensor Imaging (DTI)**, identifies changes in the white matter that makes up about half of the brain's volume, by measuring water diffusion throughout the connecting myelin-sheathed axons nearer the centre of the brain. A useful 'electrical' analogy is that the MRI identifies problems with the electrical socket, plug and wire to the appliance, while the DTI checks the insulated cables in the wall cavity and loft of the house.



More details about DTI and even more modern versions of MRI are beyond the remit of IB Diploma Psychology, but we will consider later in this section what this continual development of ever more refined ways of measuring minute brain changes means.

Evaluation of MRI

- **Strengths:** MRI scans produce detailed 3D images that can be used to diagnose tumours, bleeding in the brain, and damage caused by injury, infection or stroke.
- Because MRI does not use x-rays or other radiation, it is the imaging method of choice when frequent imaging is required for diagnosis or therapy, especially in the brain. The quality of the images is improving over the years, although they often depend on how still the patient lies, as movement can affect them.
- **Limitations:** MRI scanning is very noisy, and children, people with claustrophobia and patients with certain diseases may find it extremely difficult to stay still for times of between 30 minutes and 1 hour in the scanner, which they need to do, as movement can affect the quality of the images.
- Because of the magnetism, it should not be used on people with metal inserts in their bodies, especially those containing iron.
- MRI scanning is much more expensive than CT scanning, and therefore not all hospitals, especially those in developing countries, can afford MRI scanners or can afford to use them for all but the most severe cases. Moreover, there is a cost associated with training health personnel to correctly interpret the scans.

Key Study: Maguire et al. (2000)

Aim: To examine whether structural changes could be detected in the brain of people with extensive experience of spatial navigation.

Method: Structural MRI scans were obtained. 16 right-handed male London taxi drivers participated; all had been driving for more than 1.5 years. Scans of 50 healthy right-handed males who did not drive taxis were included for comparison. The mean age did not differ between the two groups.

Results:

- Increased grey matter was found in the brains of taxi drivers compared with controls in the right and left hippocampi. The increased volume was found in the posterior (rear) hippocampus. The anterior hippocampal region was larger in control subjects than in taxi drivers.
- Changes with navigation experience – a positive correlation was found between the amount of time spent as a taxi driver and volume in the right posterior hippocampus.

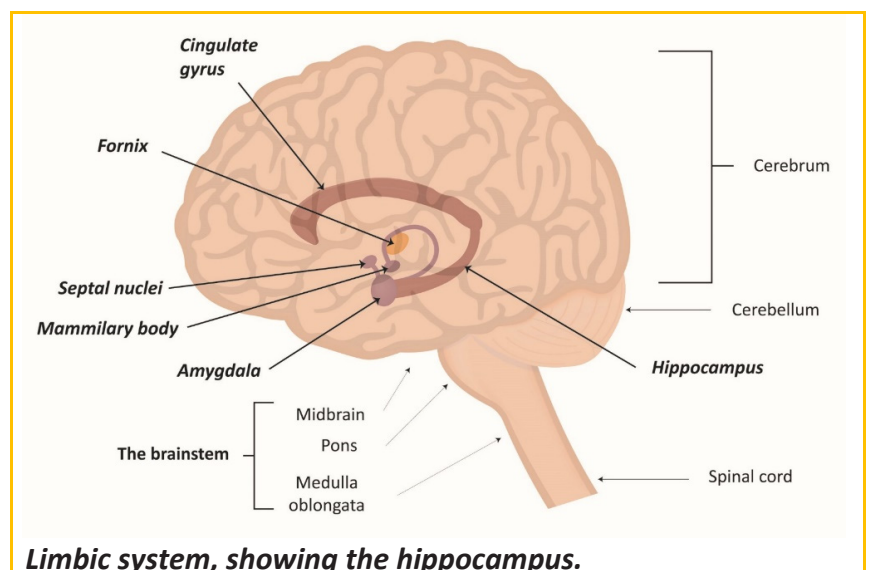
Conclusion: The results provide evidence for structural differences between the hippocampi of London taxi drivers and control participants, therefore suggesting that extensive practice with spatial navigation affects the hippocampus. This demonstrates that the brain can change in response to environmental demands.

Evaluation of Maguire et al. (2000)

- Strengths:** Many extraneous variables are controlled: the mean age, the handedness and the gender of the two groups were the same. Moreover, the scans of the 50 control participants were selected from the structural MRI scan database at the same unit where the taxi drivers were scanned, suggesting that the same MRI scanner was used, which is another controlled variable. However, the results only show a correlation: it is possible that people with larger than normal posterior hippocampi are attracted to careers that use their spatial abilities, including taxi driving. But the fact that there was a positive correlation between the number of years spent as a taxi driver and the volume in the right posterior hippocampus would tend to counteract this argument. The researchers were also careful to only choose brain scans from healthy non-taxi drivers as a control group.
- Limitations:** The MRI scans of these non-taxi drivers were obtained from a London hospital, which raises ethical issues regarding informed consent and use of data. This is, as mentioned above, just a correlation, and no cause and effect relationship can be determined.

Critical Thinking

Why did the posterior hippocampus change more on the right-hand side with these right-handed drivers? This is strange, considering that the left brain hemisphere generally controls the right side of the body, so we might have expected the left hippocampus to show the most change. A follow-up comparison with left-handed drivers, with female drivers and with a larger group, is called for, as 16 people is not many on which to base a theory of **localization of brain function** (see the next section for discussion of localization).

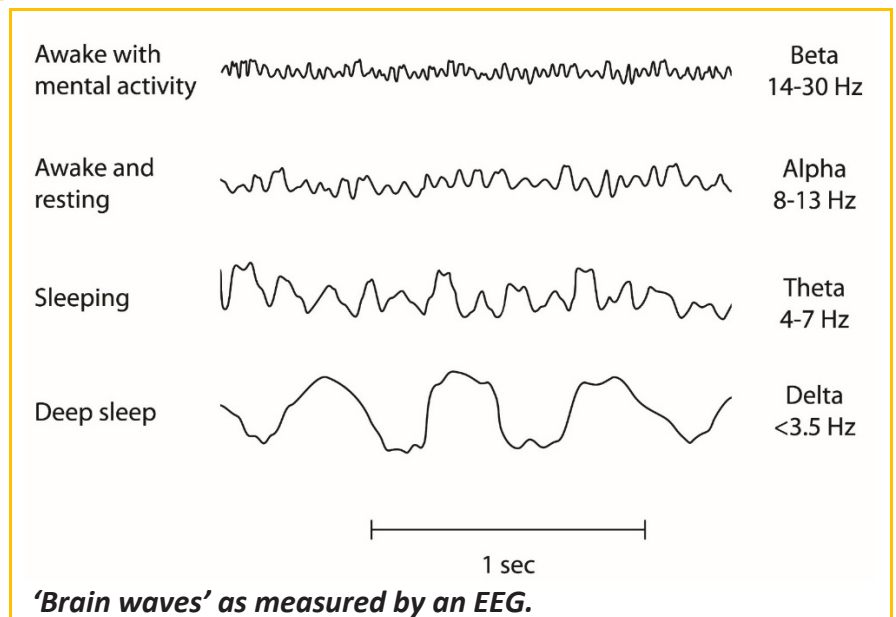


Techniques Investigating Brain Processes

Techniques investigating brain processes measure changes in the brain activity (rather than structure) often while the person carries out a simple cognitive task.

Electroencephalogram (EEG)

An EEG is used to measure and evaluate electrical activity in the brain. It works through electrodes being attached to the person's scalp, and they analyse the electrical activity and send the results to a computer. Unlike a CT or MRI scan, the results are not a brain image as such, but an activity graph of peaks and valleys that record the level of brain activity. This graph has been described as showing 'brain waves'. An EEG is often used to investigate a person for epilepsy, to measure brain activity after an injury or stroke, to examine sleep problems and to test for dementia.



Evaluation of EEG

- **Strengths:** EEG is one of the cheapest ways to identify brain processes, namely the electrical activity in the brain.
- One of the biggest advantages to EEG is the ability to see brain activity as it unfolds in real time, at the level of milliseconds, and movement does not affect the scan.
- **Limitation:** With EEG, it is sometimes difficult to tell where activity is coming from, especially if it is happening in two brain areas at the same time.

Positron Emission Tomography (PET)

PET scans use a radiotracer of radioactive material that is attached usually to either glucose or oxygen to allow them to be traced in the brain as a person undertakes a particular activity. The more energy a group of cells needs, the more the radiotracer collects in a certain location. For example, cancer cells are very active in using glucose, so a radiotracer attached to glucose will show up a cancerous brain tumour. Conversely, brain cells affected by Alzheimer's disease take up glucose more slowly than other cells, and so the PET scan can also identify these.

Evaluation of PET

- **Strengths:** PET scans produce images of brain activity that are also not affected by small movements, and because they study body function through biochemical functions they are able to detect disease before changes in the anatomy become apparent making PET scanning more effective in diagnosing than other imaging tests. For example, in its early stages, Alzheimer's disease does not produce gross structure abnormality, so is difficult to detect in CT and MRI. However, it produces biochemical change, which a PET scan is able to detect.

- PET imaging can also be used in conjunction with an MRI or CT scan as a way to examine what biochemical changes have occurred in an organ or tissue that has been shown to have changed anatomically. Consequently, PET imaging is an important imaging tool in cancer detection as it is able to distinguish between benign (alive tissue) disorders and malignant (dead tissue) disorders.
- **Limitations:** PET scans do not produce such a clear image as an fMRI does (see below). Also, the radioactive tracer used (by injection or ingestion) makes it slightly invasive.
- PET scans can be expensive, and there also is a risk for significant radiation exposure, which raises the risk of cancer, especially when combined with CT scans.

Functional Magnetic Resonance Imaging (fMRI)

While part of the same MRI machine, a functional MRI looks at process rather than structure. It measures oxygenated blood flow in the brain: oxygenated blood has a different resonance than blood that has already delivered its oxygen to the cells and more active areas of the brain receive more oxygenated blood. Therefore, an fMRI measures brain processes through the flow of oxygenated blood to certain areas and a computer turns the images into a 3D coloured moving image of brain activity. Brain activity is mapped in squares called **voxels**, with each voxel representing thousands of neurons. fMRI has many uses, but most recently it has been used to investigate the role of the medial prefrontal cortex in severe depression.

Evaluation of fMRI

- **Strengths:** A typical fMRI scan produces 130,000 voxels in a 3D image that gives very detailed data about the relationship between brain activity and cognitive processes.
- It is now possible to undergo an EEG and an fMRI simultaneously. Recently, new technology capable of recording EEG signals from the brain while a patient is inside an MRI machine was developed. This may have caused a revolution for the study of the brain, as fMRI and EEG scans provide unique complementary insights into the brain's activity, with the EEG recording the activity in the cerebral cortex, nearer the surface of the brain, and the fMRI scanning deeper structures. Being able to visualise brain activity while monitoring electrical brain signals gives a more holistic picture of the interaction between brain areas during processes like visual analysis, memory and speech.
- **Limitations:** Like the MRI, it is expensive, and so its use is limited in some cases.
- The fMRI is slower to record activity than the EEG. However, the combination of fMRI and EEG helps to solve this problem.

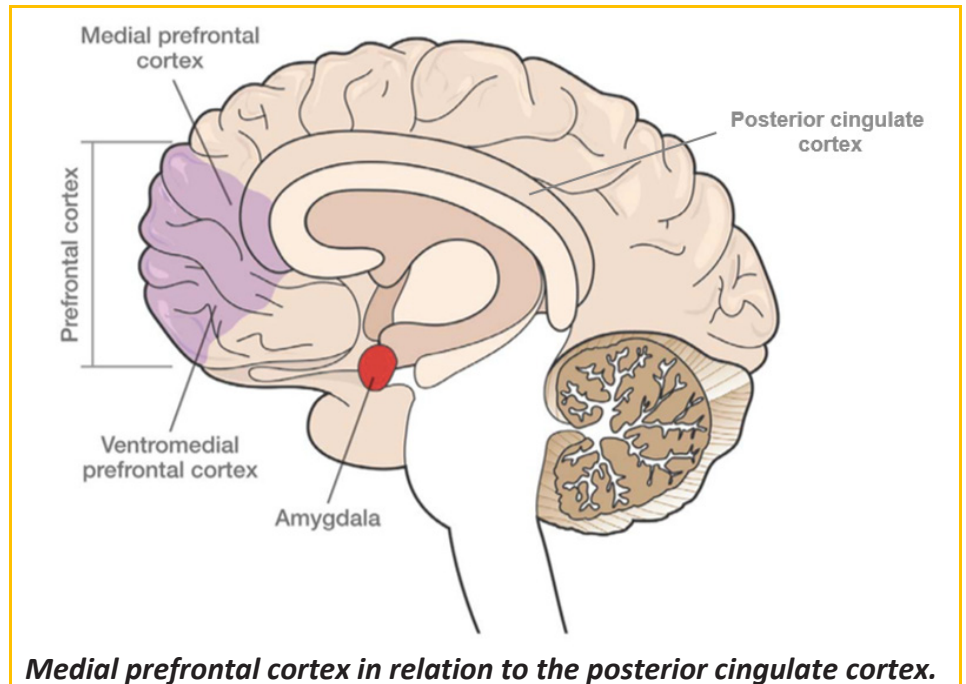
Key Study: Davey et al. (2017)

Aim: To clarify the role of the **medial prefrontal cortex** in self-appraisal processes in depression. This part of the brain has a role to play in self-appraisal, and a negative self-image has been shown to be a factor in depression. Depressed people spend more time thinking about themselves and this process has been theorised to be controlled by the medial prefrontal cortex.

Method: Participants were 71 adolescents and young adults with moderate to severe depression. A control group of 88 non-depressed adults was used for comparison. None of the participants were on any

medication. All participants were scanned and while undergoing the fMRI scan, each completed a self-appraisal task containing personal adjectives, such as 'lucky' or 'sceptical' and asked to judge which of these, if any, applied to themselves.

Results: In all participants, the medial prefrontal cortex was shown by the fMRI scan to regulate another part of the brain, the **posterior cingulate cortex**, which is located further back in the brain, with strong connections to the **cerebral cortex** and the **limbic system**. (see the image below). This part of the brain has been shown to be involved in self-directed cognition, such as autobiographical memory and personal planning. However, in the depressed participants the control exerted by the medial prefrontal cortex over the posterior cingulate cortex was particularly strong, with self-appraisal causing significantly more negative modulation of connectivity between the medial prefrontal cortex and the posterior cingulate cortex than in the control group.



For example, the depressed participants more often answered 'yes' to the question 'Does this word describe you?' Moreover, the mean likeableness ratings for words that were affirmed as describing the self were significantly lower for the depressed compared with the control group. The connectivity between the medial prefrontal cortex and the posterior cingulate cortex was even more disturbed in patients with major depressive disorder alongside social anxiety disorder.

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Conclusion: There is a correlation between changes in brain connectivity and self-appraisal. The researchers suggest that this illustrates the difficulty that depressed patients have in switching from thinking about other things to thinking about themselves, as their self-appraisal is heavily controlled. This study provides a brain model of disturbed self-appraisal in depression.

Evaluation of Davey et al. (2017)

- **Strengths:** The study focuses on young people during a formative period when self-appraisal is particularly important, and depression is less chronic and less likely to be influenced by treatments. The connectivity disturbances suggest themselves as targets for cognitive behavioural therapy aiming to change negative self-schemas. In this way, fMRI imaging has helped to isolate a biological correlation that could be treated cognitively.
- **Limitations:** The small sample and the limited age group mean that this study cannot be generalised easily. There was no group with social anxiety disorder alone, although some of the depressed participants were also suffering from this, and they showed the greatest disturbance in the connectivity between the medial prefrontal cortex and the posterior cingulate cortex. Therefore, it is not clear exactly how the disorder affected self-appraisal. Finally, neuron connections are still developing in adolescence, and it may be that the brain connectivity changes would be less or different in older depressed adults.

Critical Thinking

Away from reductionism? A common criticism of the biological approach to studying human behaviour is that it is reductionist in breaking down complex cognitions into a series of neurotransmitter actions and then trying to treat these as the only causes of said emotions, attitudes and behaviour. This study shows the benefits of combining fMRI scanning of a biological brain process with an analysis of how the findings can be used to identify how cognitive behavioural therapy works to moderate negative self-appraisals.

General Evaluation of Techniques Used to Study the Brain In Relation to Behaviour

Rarely are these techniques used in isolation: exploratory brain surgery follows scanning when the images cannot give us certainty; MRI scans that identify tumours are followed by fMRI scans that show how they are affecting brain processes and behaviour; even PET scans that suggest Alzheimer's disease are sometimes followed by brain autopsy after a person's death to confirm the diagnosis. There are certain considerations to be taken into account when using any technique to study the brain, such as the cost, potential harm to the patient and of course, confidentiality of the data. This last consideration will be discussed at the end of this chapter, under 'ethical considerations'.

Summary Table Evaluating Techniques Used to Study the Brain in Relation to Behaviour

	ADVANTAGES	LIMITATIONS
BRAIN AUTOPSY	Can allow definite post-mortem diagnosis of certain degenerative brain diseases that may aid future patients. Of most use in combination with other methods used before death.	Cannot show a direct correlation between brain and behaviour. Cannot isolate the confounding variable of brain death.
BRAIN SURGERY	Does not rely on secondary images, although scanning may be used to supplement this method.	Invasive method that could cause brain damage. Only used when scans do not show enough detail to ascertain the problem, or to treat people suffering from a mental disorder.
CT SCAN	Gives good images of blood vessels, soft tissues and bones simultaneously. Less expensive than an MRI.	Danger from radiation, especially with repeated scanning.
MRI	Useful for showing changes in the brain volume and structure as a result of learning or environment. Also shows the position and size of brain tumours or brain damage. Uses magnetism rather than radiation and therefore carries less risk than a CT or PET scan.	Cannot be used on people with metal inserts. It is very noisy, can be claustrophobic, and movement disturbs the image. This makes scanning of children and those with certain mental disorders very challenging. Expensive, and so not available to all.
EEG	Very sensitive measure of electric impulses in the cerebral cortex that is useful in diagnosis of epilepsy and sleep disorders. Relatively cheap method. No risk to patient.	Does not show the deeper brain areas, and it can be difficult to identify from which area the electrical activity is coming.
PET	Operates at the level of biochemical change and so can detect abnormalities before structural scans are able to.	Uses radiation and therefore carries some risks, especially in combination

		with CT scans. Expensive, and so not available to all.
fMRI	Produces detailed data of blood flow in the brain that can be changed into clear images to show brain activity that correlates with the activity of the person being scanned. Especially useful in combination with an EEG, to identify the exact location of the electrical activity in the brain.	All of the criticisms of the MRI apply equally to the fMRI.

POSSIBLE EXAM QUESTIONS

Short Answer Question

Explain one technique used to study the brain in relation to behaviour.

'Explain' requires a detailed account of the technique, including reasons why it may be used.

Essay Questions

Discuss techniques used to study the brain in relation to behaviour.

With 'discuss' you need to offer a considered and balanced review that includes a range of reasons why certain techniques are used over others. Opinions or conclusions should be presented clearly and supported by appropriate evidence.

Contrast two techniques used to study the brain in relation to behaviour.

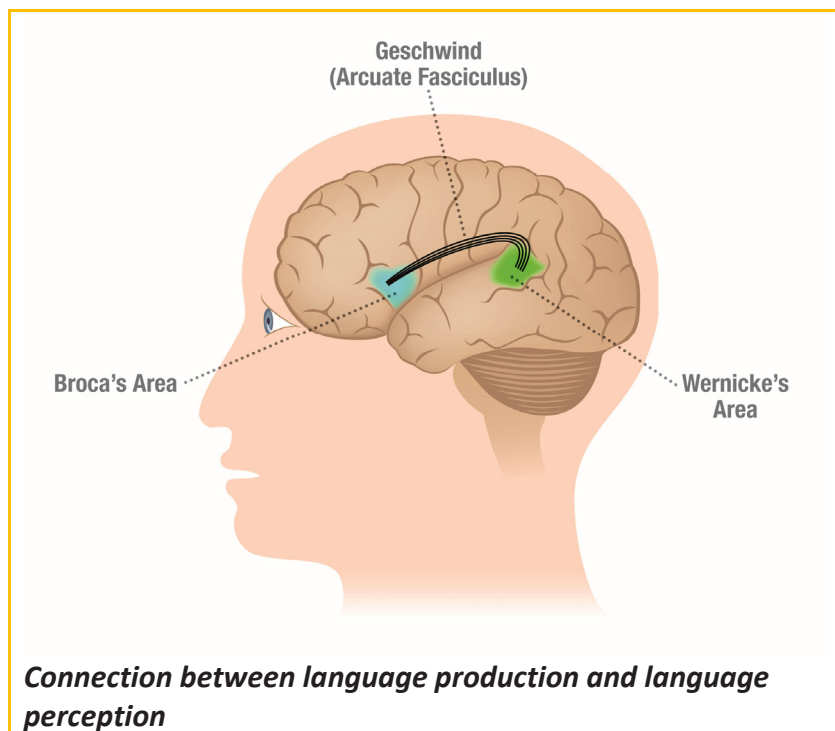
'Contrast' means that you should give an account of the differences between the two techniques, referring to both of them throughout.

PART 1B: LOCALIZATION

Key Question: *To what extent is there a relationship between certain behaviours and activity in corresponding areas of the brain?*

Introduction

Localization of brain function refers to the theory that different parts of the brain are responsible for different aspects of human functioning, such as behaviours. This relates directly to the assumption of the biological approach that cognitions, emotions and behaviours are products of the anatomy and physiology of our **nervous system** and **endocrine system**. Psychologists investigating localization of brain function from the biological approach use brain-imaging techniques, brain surgery and brain autopsies, as described above, to investigate the correlation (relationship) between brain processes and structures and human behaviour.



The theory of the localization of brain functions was developed in the mid-nineteenth century. Paul Broca (1861) discovered one of the important areas in the brain that is responsible for speech, now called **Broca's area**, in the frontal lobe of the dominant side of the brain, which is usually the left side. He discovered this by performing an autopsy on the patient Louis Leborgne, who had the nickname 'Tan' because of his inability to say anything other than this sound. At the post-mortem examination, abnormalities were found in this region of Leborgne's brain, suggesting that this was responsible for his aphasia. A few years later, in 1874, Wernicke similarly discovered **Wernicke's area**, also in the dominant

hemisphere, but this time in the temporal lobe and concerned with the understanding of speech. The **arcuate fasciculus** is the bundle of nerve fibres which acts as the connecting neural pathway between the two areas. A hundred years later, the neuroscientist Geschwind hypothesised that this was vital for language to take place and to be understood. Therefore, language was understood to be localized in these areas.

Broca and Wernicke's historical discoveries suggested that language is located in a certain area of the brain. The more modern key studies described in the previous section, but especially **Maguire (2000)**, can be used to demonstrate a correlation between an area of the brain and human behaviour, in this case, the hippocampus and spatial memory and learning. The posterior hippocampi in both sides of the brain (and more especially the right side) grew in response to the demands of learning the routes through London, while the anterior hippocampi were smaller than those of the control group, so it seems that matter may have moved from the front to the back of the hippocampi, demonstrating a correlation between learning and brain changes.

Distribution of Brain Function

However, despite the evidence supporting localization of brain function, there are classical studies and more recent discoveries that lend support to the opposing theory – that of **distribution of brain function**. The psychologist Karl Lashley conducted research in the 1920s and onwards attempting to find the part or parts of the brain where learning and memory were localized, a structure he and others called the **engram**. He trained rats to perform specific maze-running tasks, and then lesioned varying portions of the rat cortex, either before or after the animals received the training, depending upon the experiment. The *amount* of cortical tissue removed had specific effects on acquisition and retention of knowledge, but the actual location of the removed brain tissue had no significant effect. This led him to conclude that memory and learning are not localized but are widely distributed across the cortex.

Later thinking is that localization of certain types of memory (such as spatial memory, as we saw with Maguire), of emotion and of language functions exist, but that distribution also takes place. Attention is focused recently on neural pathways and mapping of **connectomes** (neural networks), with the Human Connectome Project that was set up in 2010 receiving large grants from the National Institute of Health to map the neural pathways of the human brain (NIH, 2010).

The neuroscientists Tremblay and Dick wrote a series of articles between 2010 and 2013 arguing that language production and language comprehension are processed in a distributed way in the cortex and deeper areas of the brain. They take issue with the tripartite Broca-Wernicke-Geschwind model of localization of language production in Broca's area, language comprehension in Wernicke's area and transmission between the two through the arcuate fasciculus, as Geschwind hypothesised. Instead, they argue that fMRI imaging shows that large parts of the left and right cortex are involved in language production and perception. Their theory of distributed function is detailed in a complex article that you may wish to read (Dick, Bernal & Tremblay, 2013). Their study summarised below lends support to this theory, and is much more simply written. The background to this study was laid in 2009, when a study comparing memory for visual stimuli in children and adults found age differences in which brain structures were used, which needed further research (Dick, Solodkin & Small, 2009).

Key Study: Tremblay, Dick & Small (2013)

Aim: To investigate functional and structural age-related differences in the cortical network of nerve fibres that support speech perception and production, as well as investigate the relationship between functional and structural age-related changes occurring in this network.

Method: Young and older adults were asked to watch videos of a speaker producing single words (perception), and to observe and repeat the words produced (production). The young adult group comprised 20 healthy right-handed native English speakers aged between 18 and 38 years old (11 female and 9 male), with between 12 and 18 years of education. The older group comprised 19 healthy right-handed native English speakers aged between 57 and 70 years old (11 female and 8 male), with between 13 and 22 years of education. Their hearing sensitivity and ability to discern speech were tested. This quasi-experiment consisted of 2 tasks: (1) observation of a set of short video clips showing a female actor producing words (Perception); and (2) observation of a set of similar videos followed by repetition of the word produced by the speaker (Production). An fMRI scan was used on participants throughout the tasks.

Results: The young participants committed a total of 15 errors in more than 960 trials. The older participants committed a total of 14 errors in more than 960 trials. Results showed a widespread bilateral network of brain activation for perception and production that was not correlated with age. In both groups, perception activation included a large cluster stretched across the temporal lobe on both sides of the brain. For production, activation included additional bilateral clusters in the ventral primary motor

cortex. In addition, several regions showed age-related structural changes in the density of the grey matter, with the younger participants having significantly denser grey matter in the cortical brain regions.

However, examination of the relationship between brain signal and regional and global grey matter volume and cortical thickness revealed a complex set of relationships, with some regions showing a relationship between structure and function and some not. Speech performance (repetition of audio-visual words in noise) was similar across groups, which suggests that the neural system supporting speech production is capable of coping with a certain amount of functional and structural brain changes.

Conclusion: The theory of the distribution of brain function was supported by the findings, and, while the structural differences in the brain were consistent with the hypothesis of decreased neural functioning, despite the absence of a difference in behavioural performance between groups, the neural functioning level was still sufficient to maintain performance, especially during this low-difficulty speech repetition task.

Evaluation of Tremblay, Dick & Small (2013)

- **Strength:** The use of the scan while the tasks were completed allowed objective observation of the results of language perception and production on several brain areas simultaneously.
- **Limitations:** In the older age group, many participants were in their late 50s and early 60s, which is on the very early edge of older age, and therefore it may be that the structural decline of grey matter may not yet have been sufficient to result in deterioration of function.
- This is a small sample of 39 participants in total, which may not be enough for drawing reliable conclusions. The study focuses on single word processing and does not attempt to discuss how words are combined to generate sentences.

Critical Thinking

Is the localization vs. distribution debate another instance of a false binary? Just as we now recognise that the nature vs. nurture binary is a false construction and there is interaction between the two, so the localization vs. distribution of function binary is appearing to be the same. It seems that it is possible to have areas of localization joined by neural pathways that together make a **connectome** – a neural network across which a certain function or behaviour is distributed. For example, later research by Maguire and other researchers into the retrosplenial cortex area in the posterior cingulate cortex, deep in the mid-brain just towards the back of and above the corpus callosum, found that it also is responsible for spatial memory (Vann *et al.*, 2009). Yet this is some distance from the hippocampus, and Kravitz *et al.* (2011) outline in some detail the neural pathways that connect these two areas. So this is where research is now: localized areas (rather than one area) connected by neural pathways (not just one pathway). The means of ascertaining this is mainly fMRI and PET scans, which show more than one area responsible for one human behaviour.

Application of Research into Localization of Brain Function

The technological advances that have allowed us to understand ever more regarding the localization of brain function have also developed our understanding of how medication affects certain areas of the brain: fMRI scanning allows the investigation of regionally specific brain activity associated with the administration of medicines designed to change the activity in a certain brain area, especially in people with diseases of the brain, such as Alzheimer's Disease or Huntington's Disease.

POSSIBLE EXAM QUESTIONS

Short Answer Question

Outline localization of brain function, using one relevant piece of research to support your answer.

'Outline' needs you to give a brief account or summary of localization of brain function, supported by an example of research.

Essay Questions

Evaluate the theory of localization of brain function, using research to support your answer.

With 'evaluate' you need to make an appraisal by weighing up the strengths and limitations of the theory of localization. Opinions or conclusions should be presented clearly and supported by appropriate evidence.

To what extent can human behaviour be explained through localization of brain function?

'To what extent' requires an argument for the explanatory power of localization and evidence both supporting and limiting this as an explanation, and possibly giving an alternative explanation.

PART 1C: NEUROPLASTICITY

Key Question: *How does the brain change in response to learning and the environment?*

While psychologists working from the biological approach proceed from the assumption that cognitions, emotions and behaviours are products of the anatomy and physiology of our nervous and endocrine systems, they do not believe that these systems operate in isolation from the surrounding environment.

Therefore, research is conducted to investigate how our environment and our learning can affect brain activity and even brain structure. While Maguire's taxi driver study has been described in our earlier sections to demonstrate the utility of MRI scanning and as an example of localization of brain function, the fact that the taxi drivers' hippocampi showed changes mean that the results of this study also demonstrate neuroplasticity. Besides spatial learning and memory, another area that has attracted psychologists' attention is cognitive development in childhood. Observed cognitive differences between children from low socio-economic status (SES) families and those from a wealthier background show that the brain is strongly affected by the environment from a very early age. The study below shows that neuroplasticity of the brain in response to poverty can be mediated by caregiving and exacerbated by stress.



Key Study: Luby et al. (2013)

Aim: To investigate whether poverty experienced in early childhood impacts brain development at school age and to explore the mediators of this effect.

Method: A total of 145 right-handed children were recruited from a larger sample enrolled in a 10-year longitudinal Preschool Depression Study, to investigate the effects of poverty on brain development. Children were cognitively and socially assessed annually for three to six years before they underwent two MRI scans, one of the whole brain and one of the amygdala and hippocampal areas. During this pre-MRI period of time they were evaluated on psychosocial, behavioural and other developmental dimensions. The support or hostility of their caregivers was also noted during this testing period. The existence of stressful life events experienced was another variable that was measured. The MRI scans measured the brain volumes of white matter and cortical grey matter, as well as volumes of the hippocampus and amygdala.

Results: Poverty was associated with less white and grey brain matter and with smaller hippocampus and amygdala volumes. However, whether the caregiver was supportive or hostile mediated the effects of poverty on both hippocampi, while stressful life events affected the volume of the left hippocampus only.

Conclusion: The finding that exposure to poverty in early childhood impacts brain development at school age draws attention to the effects of poverty on child development. Finding that these effects on the hippocampus are mediated by caregiving and stressful life events suggest that attempts to enhance early caregiving should be focused on.

Evaluation of Luby et al. (2013)

- **Strength:** This study extends earlier animal studies into the role of nurturing in hippocampal development and earlier child studies showing that this effect is independent of income. It gives us a complex picture of the mediating effects of stress and nurturing that needs to be investigated further. Changing economic and social status can be difficult. However, interventions at the level of caregiver support will, according to the results of this research, have a beneficial effect and may be easier to manage.
- **Limitations:** The study sample, because of the larger sample from which it was taken, contained many pre-schoolers with symptoms of depression, limiting generalizability.
- The relationships in the mediation model may be bidirectional, meaning that it could be the active response of the child to the caregiver that is showing in the brain changes. This reduces the internal validity of the study.

Critical Thinking

A useful addition to the literature on the interaction between nurture and nature and cognitive development. The application of these findings is obvious in social policy, and the results of this study can be used to counteract now outdated arguments that intelligence is determined by genetic inheritance, and also to counteract arguments that state a simplistic uni-directional and unmediated effect of poverty on the brain in childhood. However, what is missing is any consideration of both why some caregivers (usually parents) are more supportive than others and any observation of the child's response to the type of nurturing they received. The role of supportive caregiving in preventing the negative effects on the brain of stressful life events is another variable that needs further research.

Application of Research into Neuroplasticity

An application of the knowledge that neuroplasticity takes place as the brain changes in response to disorders like depression and anxiety is to look at ways in which these changes could be interrupted, and maybe even reversed, in an effort to 'heal' the brain and thereby decrease the symptoms. Given the findings above, maybe social support of those with mental disorders would be enough to mediate the brain changes associated with them, as an alternative to medication?

POSSIBLE EXAM QUESTIONS

Short Answer Question

Explain neuroplasticity, using one relevant piece of research to support your answer.

'Explain' requires that you give a detailed account of neuroplasticity, including the process of how it happens.

Essay Questions

Discuss neuroplasticity in relation to the brain and human behaviour, using research to support your answer.

With 'discuss' you need to offer a considered and balanced review of the theory of neuroplasticity. Opinions or conclusions should be presented clearly and supported by appropriate evidence.

To what extent can neuroplasticity explain human behaviour?

'To what extent' requires an argument for the explanatory power of neuroplasticity and evidence both supporting and limiting this as an explanation, and possibly giving an alternative explanation.

PART 1D: NEUROTRANSMITTERS AND THEIR EFFECT ON BEHAVIOUR

Key Question: *How does neurotransmission affect human behaviour?*

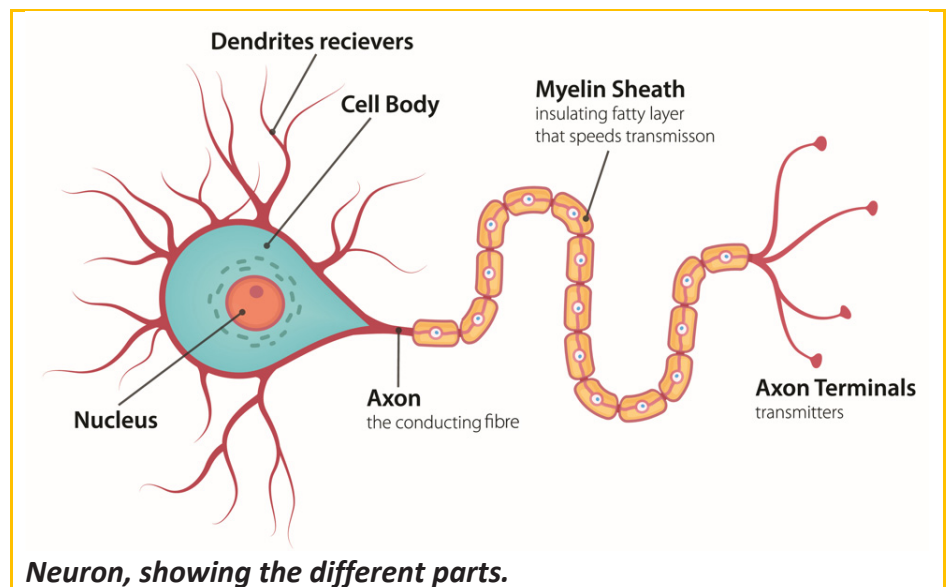
Introduction

The **neuron** is the basic unit in the **nervous system**. It is a specialized cell that receives and transmits electrochemical nerve impulses. Over three-quarters of all neurons are found in the brain, and there are three types:

- **sensory (afferent)** – carrying information from the sense organs to the central nervous system (brain and spinal column).
- **motor (efferent)** – carrying information from the central nervous system to the muscles and glands.
- **connector** – the most numerous by far, and they connect neurons to other neurons and coordinate the activities of motor and sensory neurons.

Neurotransmitters are chemicals that carry the electrical impulses between neurons in the brain and body. They act within the synapse (the gap between two neurons). Note that not all neurotransmitters are taken up by the receptors of the receiving neuron. Some stay in the synapse and many are eventually reuptaken by their originating neuron. Neurotransmission is a very fast process: the electrical signal passes along the axon at roughly 150 metres per second, and so most neurotransmission takes only a tiny fraction of a second.

The process of electrochemical transmission starts in the **dendrites** that branch out from the cell body and receive incoming electrochemical impulses from neighbouring neurons. The impulse passes down the axon as an **action potential**, down to the **terminal buttons**, containing **synaptic vesicles** (tiny sacs) filled with a neurotransmitter. This neurotransmitter is released into the synapse between the two neurons, as mentioned above.

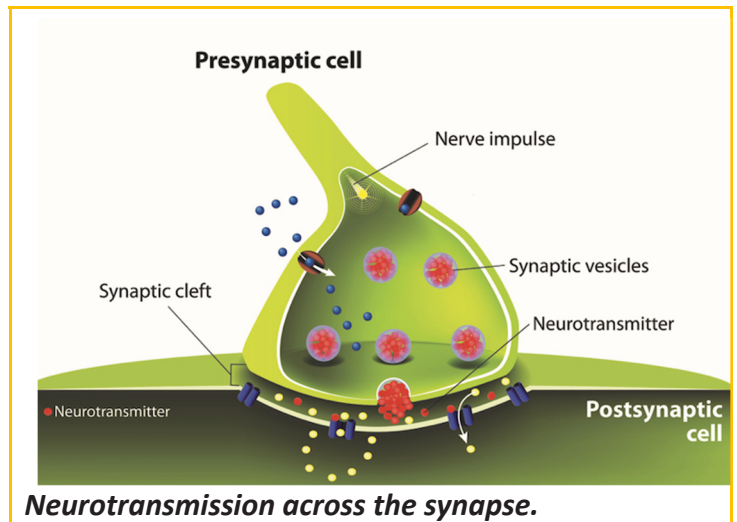


Synapses can be either excitatory or inhibitory: they can either instruct the receiving neuron (post-synaptic neuron) to fire or not to fire. It is the action of the particular neurotransmitter in the terminal button which makes a synapse either excitatory or inhibitory. As a rule, a single neuron will store and release the same neurotransmitter in all of its terminal buttons. But each neurotransmitter can act in either an excitatory or an inhibitory way: acetylcholine is usually excitatory, but can be inhibitory, depending on the receptor neuron; serotonin is both excitatory and inhibitory.

Finally, neurotransmitters are affected by chemicals that bind to the receptor sites: **agonists** which increase the neurotransmitter effect (making the excitation or inhibition stronger) and **antagonists** which reduce their effect (making the excitation or inhibition weaker).

Research into the action of neurotransmitters has often used animals, and this aspect will be discussed in the section devoted to the HL extension. Meanwhile, here we look at studies researching their effect on human behaviour.

The levels of the neurotransmitter **acetylcholine (ACh)** are raised when we are awake and active, but in order to consolidate memories of what has happened in the day, researchers are aware (through studies using rats) that deep sleep is needed. Therefore the role of acetylcholine in the processing of these memories while we are asleep was further investigated, using humans.



Key Study: Gais and Born (2004)

Aim: To investigate the role of the neurotransmitter acetylcholine (ACh) in the human hippocampus while a person is in slow-wave sleep.

Method: Twenty-nine healthy male participants aged between 18 and 35 years old engaged in one adaptation night and two experimental nights. They were split randomly into two groups, and all participants in both groups completed a word memory task (declarative/explicit memory) and a mirror-image tracing task (non-declarative/implicit memory) between 10 and 10.30 pm. On the first night, beginning with sleep onset (sleep experiment) or at 11:15 pm (wake control experiment), subjects received an infusion of physostigmine, which stimulates acetylcholine production, over two hours. On the second night, all participants received a placebo (saline solution).

The participants in the experimental 'sleep' group were awoken three hours after falling asleep and asked to recall the words they remembered and to complete the tracing task. The control group stayed awake, and they were asked at the same time as the experimental group to recall their words, and to complete the tracing task.

Results: During sleep, memory for the declarative wordlist task distinctly decreased after administration of physostigmine as compared with the placebo condition. In the wake condition the elevation of acetylcholine did not result in decreased memory performance but in an insignificant increase in wordlist recall as compared with that in the placebo condition.

On the other hand, neither speed nor accuracy in the non-declarative mirror-tracing task decreased after physostigmine administration in either the experimental or control conditions.

Conclusion: Acquisition of declarative information (learning and memory for events) when we are awake needs the higher acetylcholine levels that have been noted in previous experiments with rats. However, the processing and storage of the materials into neocortical networks require a period of low acetylcholine levels to prevent suppression of feedback from the hippocampus to the other areas of the brain. So, *high* acetylcholine is needed for information to be retained in the hippocampus, and *low* acetylcholine is needed for that information to enter long-term memory.

Evaluation of Gais and Born (2004)

- **Strength:** As the researchers themselves note, this is a logical conclusion from the earlier rat studies and their own research. Acetylcholine levels seem to mediate the direction of information flow.
- **Limitations:** However, this was a small experiment on males only and therefore has gender bias. Also, there was a limited age range of the participants (between 18 and 35 years old) and the experiment needs to be repeated with older participants, and with a gender balance and a mixture of ethnicities, in order that the results may be replicated and the reliability of this experiment be established.
- Ethically, as physostigmine can have unpleasant side-effects, there was a small risk of physical harm and mental stress being caused to participants.

[Note: some critics have suggested that the amount of short-wave sleep is relevant, but the researchers found that memory was not only impaired with an extreme lack of sleep: it did not improve if the amount of sleep was increased.]

Faulty Neurotransmission

Research into the operation of neurotransmitters has often focused on faulty neurotransmission that has been suggested to be correlated with a particular behaviour. The next study is investigating a connection between a genetically inherited polymorphism in the serotonin transporter gene and incidence of depression as a response to stress.

The serotonin transporter gene (5HTT gene) has received specific attention because it is related to the re-uptake of the neurotransmitter serotonin in the brain synapses. It was suspected that adaptations in this gene in what is known as the 5HTTPR (polymorphic region) affected the incidence of depression in an individual. This is a study that can be used in the abnormal psychology option, and we will also come across it again when looking at genetics and behaviour.

Key Study: Caspi et al. (2003)

Aim: To investigate whether a functional change in the 5HTT gene is linked to a higher or lower risk of depression in an individual.

Method: The researchers used an opportunity sample from a **cohort** of participants who were part of another longitudinal study. There were 847 participants of 26 years old and they were split into three groups, depending on the length of the **alleles** on their 5HTT transporter gene.

Group 1 – two short alleles

Group 2 – one short and one long allele

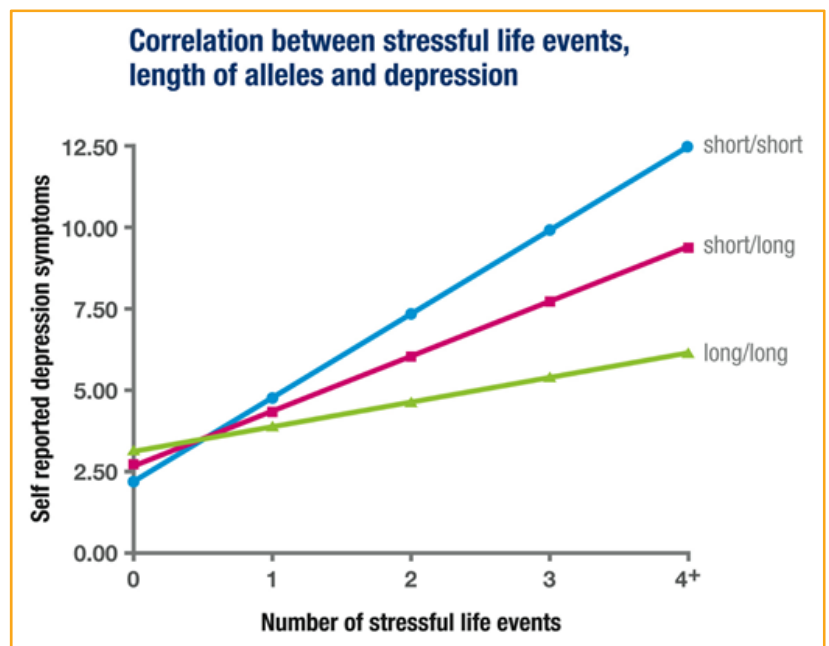
Group 3 – two long alleles

1. Stressful life events occurring after the 21st birthday and before the 26th birthday were assessed using a life-history calendar.
2. Past-year depression was assessed using the Diagnostic Interview Schedule.
3. A correlation was tested for between stressful life events and depression, between the length of the alleles and depression, and an interaction between perceived stress and the length of the alleles.

4. A further test was done to see if life events could predict an increase in depression over time among individuals with one or two short alleles.

Results: As the graph below shows, the participants with two short alleles on the 5HTT gene reported more symptoms of depression in response to stressful life events than either of the other two groups. Those participants with two long alleles reported fewer depression symptoms. Moreover, childhood maltreatment was predictive of depression in adulthood only in adults with either one or two short alleles.

Conclusion: While there is no *direct* relation between short alleles on the 5HTT gene and depression, there is a relationship between these and incidences of stress and subsequent depression. The long alleles seem to protect against suffering depression as a result of stress. The effects of the gene adaptation are dependent on environmental exposure to stress.



Evaluation of Caspi et al. (2003)

- **Strengths:** This was a very large cohort of males and females and the age was controlled in order to isolate the variable of number of stressful life events between the ages of 21 and 26. It was a quasi-experiment, with the naturally occurring IV being the length of the alleles, by which they were split into groups. If the results are replicated this would suggest high reliability.
- **Limitations:** Gene and neurotransmitter action is highly complex, and actions of other genes and neurotransmitters could not be controlled. Therefore the results may lack validity.
- While the stressful life events were standardised as employment, financial, housing, health and relationship, whether or not a participant experienced a certain event as stressful is highly personal. This could suggest a lack of construct validity – the terms did not mean the same to all participants.
- Moreover, the symptoms of depression were self-reported, although one colleague was contacted for each participant in order to verify the symptoms. Self-reporting can be unreliable.

Critical Thinking

The death of reductionism? It has been argued that the biological approach, and especially brain imaging in order to isolate the one brain structure or one area of brain activity that was correlated with a certain behaviour, is reductionist. However, when imaging is used to complement cognitive testing (as with Luby *et al.*, 2013) and to investigate interrelationships between brain, environment, inheritance and behaviour, surely we should now be seeing it as part of a holistic picture? Even when it is clear that brain damage alone is responsible for a mental or physical disorder, treatment for that disorder will exploit the brain's plasticity, to stimulate other neural networks to take over functions, and on psychosocial support to ensure the optimal conditions for doing so.

Application of Research into Neurotransmission

Gais & Born's findings could have a useful application for those with Alzheimer's disease, as drugs which block acetylcholine in the brain could be used to decrease the amount of acetylcholine during sleep, and so aid memory consolidation.

Neurotransmitters are made up of amino acids from the food we eat, and knowing this can encourage a healthy diet high in essential amino acids, although be aware that not all of these find their way into the brain across the blood-brain barrier. However, some do, and an understanding of the links between diet and mental as well as physical health is improving every day.

More and more research is exploring interactions between genes, neurotransmission, environment and behaviour to give us a holistic picture of brain functions and correlations between all of these factors and human behaviour.

POSSIBLE EXAM QUESTIONS

Short Answer Question

Describe neurotransmission, using one relevant piece of research to support your answer.

'Describe' requires that you give a detailed account of neurotransmission, using a study or theory to support your answer.

Essay Questions

Evaluate one or more relevant pieces of research into neurotransmission and its effect on human behaviour.

With 'evaluate' you need to offer a considered and balanced review of the research, focusing on its strengths and limitations. Opinions or conclusions should be presented clearly and supported by appropriate evidence. If using one piece of research, others may be introduced as part of the evaluation.

To what extent can neurotransmission explain human behaviour?

'To what extent' requires an argument for the explanatory power of neurotransmission and evidence both supporting and limiting this as an explanation, and possibly giving an alternative explanation for human behaviour that is less focused on the actual process of neurotransmission.

APPROACHES TO RESEARCH PART 1: BRAIN AND BEHAVIOUR

Methods of investigating the brain and behaviour often take an etic approach, looking for universal laws regarding correlations between brain structure and activity and human behaviour. Case studies, lab experiments, and quasi-experiments are all used commonly in the biological approach. Approaches to research will have their own chapter, so here we are just concentrating on their relevance to the brain and behaviour.

Case study: The case study conducted into the behaviour of Henry Molaison was a very long case study into an individual. It lasted 55 years, from his original surgery in 1953 until his death in 2008. In fact, with the preservation and later slicing of his brain described earlier in this chapter, we could say he is still being studied. It had many characteristics of a case study:

- Triangulation of methods and data – cognitive interviews, MRI scans and observations.
- Triangulation of researchers – the psychologists Brenda Milner and Suzanne Corkin and their students.
- A longitudinal approach – data was collected over a long period of time, and the researchers both became very familiar with HM as a participant in this research. Both of them spoke of him as a friend. This researcher involvement is common in case studies.

Case studies allow an in-depth investigation into a phenomenon, in this case complete **anterograde amnesia** (memory for events after the surgery) and partial **retrograde amnesia** (memory for events before the surgery) after surgery designed to cure severe epilepsy. While results are not always able to be generalised, they can be used to create theory, in this case theory regarding the relationship between **episodic memory** and the medial temporal lobe region of the brain, including the hippocampus and amygdala.

Lab experiment: Gais & Born's (2004) study into the effect of ACh on consolidation of memories during sleep was a lab experiment. The participants were randomly assigned to two groups, and although both groups received the physostigmine and saline solution (placebo) injections, only one group was allowed to sleep, so the presence or absence of sleep was the manipulated independent variable (IV), and the effect of this on memory was the dependent variable (DV), which was measured under both the physostigmine and placebo conditions. Lab experiments are designed to control variables that might affect the results, so they take place in controlled conditions, which often means that participants may not act as naturally as they would do in their own familiar settings. For example, the quality of sleep when observed in a sleep lab is not the same as when at home in your own bed. Therefore, it could be argued that the results may not be generalizable to more natural conditions – they lack ecological validity. However, because variables were controlled, the researchers could argue for a cause-effect relationship between acetylcholine and memory.

Quasi-experiment: The word 'quasi' means 'seeming' or 'resembling', so think of this as a 'seeming-experiment'. A quasi-experiment has an IV, but no random allocation to conditions/groups, which gives non-equivalent groups - e.g. male/female; young/old; learner driver/experienced driver, and therefore this a variable that is not controlled. Allocation to groups is by self-selection or by administrator selection (like comparison of two different classes of children in a school).

Tremblay, Dick & Small's (2013) research into the distribution of brain function is a quasi-experiment, because the participants were split into two groups by age, therefore they were not randomly assigned. The area of interest was the functional and structural age-related differences in the cortical network of nerve fibres that support speech perception and production, and therefore using two different age groups was logical, but does mean that this is not a true experiment.

Caspi *et al.*'s (2003) study into how different lengths of alleles on the 5HHT gene affect the response to stress is an example of a quasi-experiment, as the length of the participants' alleles were what was used to split them into groups and then measure their responses. Quasi-experiments are very useful to show behavioural differences between naturally-occurring groups, such as male/female groups, younger/older groups, etc. However, because they are not true experiments (the assignment to groups is not random) only correlations can be discovered, not a cause-effect relationship.

Note: The methods used to investigate the brain and behaviour often involve brain imaging technology. However, this technology is not a method in itself: scanners are tools that provide data for researchers.

ETHICAL CONSIDERATIONS PART 1: BRAIN AND BEHAVIOUR

It is very important to consider how your research might affect your participants. Particular concerns might be how they could respond to the discovery, through imaging, of an unexpected brain abnormality; how they feel at the end of a long case study when the connection with the researcher and the research is broken; or their ability to give informed consent if they are suffering from a mental disorder.

Informed consent: If, like HM, the participant in research is suffering from any disorder that affects their ability to give informed consent, then legal guardians need to give consent to the research. This consent should only be given once all of the participants' rights to withdraw themselves from the study have been made clear. See this *Scientific American* blog post for a discussion of this <https://tinyurl.com/l46me48>.

Debriefing: All participants should be reminded of their rights to withdraw their data from the study, and to know the results of the study, as well as, if they have requested in their informed consent, their own individual results.

Anonymity: Participants should always be known by numbers or pseudonyms during the actual research. This protects their identity from the researchers and from other participants. It is not always possible that the researcher does not know their identity at all, especially when names are collected from previous lists, but this should be a consideration. Participants in research that produces sensitive data, such as Caspi's data on tendency to respond to stress with depression should always be anonymous.

Confidentiality of data: Brain scanning used in many of these studies (such as Tremblay, Dick & Small, 2013) can show up unexpected abnormalities that may require treatment. The data belongs to the patient and it is their choice with whom to share it and whether or not to agree to accept such treatment. There are two ways of approaching this: either the participant signs an informed consent that says they don't want to know about any possibly abnormal results; or they sign to say that they agree to be informed, once physicians who are qualified to read any scans have confirmed a suspicious finding.

POSSIBLE EXAM QUESTIONS

Short Answer question

Describe one research method

used to investigate the relationship between brain and behaviour, using a relevant example of research.

'Describe' requires detail of the method chosen, but no evaluation is needed. A clear link between the method and the relationship between the brain and behaviour should be given.

Essay questions

Contrast two research methods used to investigate the relationship between the brain and behaviour.

'Contrast' requires you to show the differences between the methods, referring to these throughout the essay. Do not just describe the methods first and then contrast them; make the contrasting points the basis for your essay.

Discuss ethical considerations of biological research into the relationship between the brain and behaviour.

'Discuss' means that you should offer a balanced review of several ethical considerations that are relevant to this biological research, and use examples where possible.

BIOLOGICAL KEY TERMS

Acetylcholine (ACh)	A very common neurotransmitter that acts in the brain to increase learning and memory and in the body to stimulate muscles.
Action potential	The electrochemical impulse that passes down the axon.
Adrenaline (called Epinephrine in the US).	This is a hormone secreted by the adrenal glands at the top of the kidneys. It is responsible for maintaining normal blood pressure. In situations of stress the output is raised and this stimulates the heart to beat faster, the pupils to dilate, breathing rate to increase, and blood flow to the internal organs is diverted to the muscles. This is the 'fight or flight' response.
Adoption study	Used to investigate the proportion of human behaviour that can be attributed to genetic inheritance, and the proportion that is caused by environment. Researchers study the behaviour of adopted children and their adoptive family and natural parents, looking for correlations in behaviour, especially IQ or mental disorders.
Adrenal cortex	This is the outer portion of the adrenal gland, which is located on the top of each kidney.
Adrenocorticotrophic hormone (ACTH)	This hormone is produced by the pituitary gland in the brain, and stimulates the adrenal cortex gland to produce cortisol.
Agonist	A chemical that binds to the receptor site of a neuron and increases the neurotransmitter action.
Allele	An allele is one of two or more versions of a gene. An individual inherits two alleles for each trait, one from each parent. Research has suggested that there may be a connection between two short alleles and a predisposition to depression and between two long alleles and resistance to this.
Amygdala	Part of the limbic system. The amygdala processes emotions and plays a role in emotional memory, particularly autobiographical memory.
Androstadienone (AND)	A steroid molecule that has been identified by some researchers as a putative sex pheromone that signals maleness.
Antagonist	A chemical that binds to the receptor site of a neuron and decreases the neurotransmitter action.
Anterograde amnesia	A loss of memory for events that happened after the trauma that caused the initial memory loss. An inability to form new memories.
Aphasia	Partial or total loss of the ability to communicate verbally or using written words. A person with aphasia may have difficulty speaking, reading, writing, recognizing the names of objects, or sometimes even understanding what other people have said.
Arcuate fasciculus	A neural pathway compiled of fibre bundles that extend forward from the posterior portion of the temporal lobe to the inferior prefrontal lobe, thereby linking the Wernicke's and Broca's language areas of the brain.
Axon	A nerve fibre that conducts electrical energy away from the neuron.
Brain autopsy	Examination of the brain post-mortem to try and identify structural problems that may have affected the person while they were alive and can account for possible behaviours observed previously, and may even have led to their death.
Brain plasticity	Also called 'neuroplasticity', this is the theory (supported by research) that the brain adapts to the environment by changing in some way: either one part of the brain, as a result of injury, can take over the function of another part, or a part of the brain increases or decreases in volume, size and density in response to learning or environmental factors.

Broca's area	An area in the left frontal lobe of the brain containing neurons involved in speech production.
Cerebral cortex	This is the outer layer of the cerebrum and cerebellum, which is often referred to as 'grey matter' because the neurons here do not have the insulating myelin sheaths that other neurons possess. It is responsible for all cognitive functions, such as thinking, seeing, learning and speaking.
Cholinergic neuron	A neuron that mainly uses the neurotransmitter acetylcholine (ACh) to send its messages. The 'cholinergic projection system' refers to these neurons and their projections in the basal forebrain of mammals
Chromosome	The tiny thread-like part of the cell that carries hereditary information in the form of genes. Chromosomes come in pairs in animals; humans have 23 pairs.
Computerised [Axial] Tomography	This scan, also known as a CT or CAT scan, uses the combined data from x-rays to produce a detailed image of brain structure.
Concordance rate	The probability that a pair of individuals will both have a certain characteristic, given that one of the pair has the characteristic. Usually used in twin and family studies with regard to genetic inheritance.
Connectome	A neural network of the brain that is made up of the bundles of nerve fibres that create neural pathways through the brain.
Connector neuron	Connects neurons to other neurons and coordinates the activity of motor and sensory neurons.
Cortisol	A hormone that is secreted by the adrenal cortex glands (inside the kidneys). It is a steroid hormone related to immune functioning, and high levels, as well as having health risks, are linked to poorer performance on retrieval tasks of memory, though slightly elevated cortisol can, over the short-term improve learning and processing of information.
Declarative memory	Explicit memory ('knowing what') – memory of facts and events, and refers to those memories that can be consciously recalled or 'declared'.
Dendrites	These branch out from the cell body of a neuron and receive incoming electrochemical signals from neighbouring neurons.
Diathesis-stress theory/model	A theory stating that mental and physical disorders can develop from a combination of a genetic predisposition and environmental stress. It helps to explain why some people in a family develop mental or physical disorders and some do not, despite a genetic predisposition.
Diffusion tensor imaging	A more modern type of MRI imaging that allows a sophisticated MRI scanner to measure changes in the brain's white matter, as well as measuring the grey matter changes.
Distribution of brain function	The opposing theory to the localization of brain function, this argues that far from being localized in specific brain areas, processes like memory and learning are distributed throughout the cerebral cortex.
Dizygotic (DZ) twins	Non-identical twins (sometimes called 'fraternal twins') that result from the simultaneous fertilisation of two eggs by two sperm.
DNA methylation	A methyl group is a basic unit in organic chemistry: one carbon atom attached to three hydrogen atoms. When a methyl group attaches to a specific spot on a gene it can change the gene's expression, turning it off or on, dampening it or making it louder. It is often the process by which epigenetic changes are made.
Dopamine	A neurotransmitter that acts in the brain's rewards and pleasure areas to raise our mood. It is responsible for motivation towards rewards and is often involved in addictive behaviour. People with low dopamine are thought to be more likely to become easily addicted to substances like caffeine, nicotine,

	alcohol and some drugs, which raise the dopamine levels in the brain, and thus increase feelings of pleasure. Low levels of dopamine are related to Parkinson's Disease.
Double-blind experiment	An experimental procedure in which neither the subjects nor the researchers know the critical aspects, such as the IV and DV and/or who is in which condition. It is used to guard against experimenter bias and placebo effects.
Ecological validity	The extent to which the context and the behaviour of a study approximates to what would happen in the world generally. There is always a trade-off between experimental control and ecological validity. The more variables are controlled, usually the less is the study ecologically valid.
Electroencephalogram imaging (EEG)	A monitoring method to record electrical activity of the brain. It is typically non-invasive, with the electrodes placed along the scalp, although invasive electrodes are sometimes used. EEG measures electrical impulses in the brain, and produces a graph of these.
Endocrine system	A collection of glands distributed around the body that secrete hormones into the bloodstream to circulate the body, including the brain. These hormones regulate the metabolism of the body, and can affect cognitions, emotions and behaviour.
Engram	A hypothetical means by which memory traces are stored in the brain. The psychologist Karl Lashley spent much of his career looking for the engram.
Epigenetics	The study of how gene expression (as opposed to genetic code) can be altered through an interaction between the environment or individual lifestyle and the genome. This can even result in heritable changes being passed down from mothers to children, if the stress happens to the mother while she is pregnant.
Episodic memory	This is part of the long-term memory and is responsible for memory of events.
Estratetraenol (EST)	A steroid molecule that has been identified by some researchers as a putative sex pheromone that signals femaleness.
Etiology	The cause or causes of an abnormality or a disease.
Excitatory synapse	A synapse which on activation instructs the post-synaptic neuron to fire.
Front parietal lobe	This is a primary sensory area located near the front of the brain, behind the frontal lobe, above the occipital lobe and above the temporal lobe.
Functional MRI (fMRI)	A neuroimaging procedure using MRI technology that measures brain activity by detecting changes associated with blood flow. This technique relies on the fact that cerebral blood flow and neuronal activation are coupled. When an area of the brain is in use, blood flow to that region also increases.
Gene	A gene is a segment of DNA in a particular location on a chromosome that acts by directing the synthesis of proteins.
Gene expression	The process by which the genetic code of a gene is used to direct protein synthesis and produce the structures of the cell. Some genes are expressed continuously, as they produce proteins involved in basic physical functions; some genes are expressed as part of the <i>process</i> of cell differentiation; and some genes are expressed as a <i>result</i> of cell differentiation.
Gene regulation	The process of controlling which genes in a cell's DNA are expressed
Genotype	The inherited genetic makeup of all organisms.
Hemispherectomy	A surgical procedure of disconnection of the brain cortex on one side of the brain with that on the other. Originally it involved complete removal of one-

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