# A

# Biological approach to understanding behaviour

The relationship between biology and human behaviour can be seen as a complex interaction of **correlations**. The biological approach can be summarized with a question: To what extent do biological phenomena cause effects in human psychology? Many behaviours are biologically predetermined, but decisions made by individuals as well as **sociocultural** and physical **environmental factors** also influence biology.

Biological explanations of human behaviour show the clear influence of the natural sciences on the human sciences. For example, many biological explanations are **reductive** in nature and resort to experimentation to claim **validity**. Moreover, the technology available to investigate the relationship between biological phenomena and behaviour is becoming ever more sophisticated, allowing for new understanding.

The biological approach to behaviour focuses on:

- the brain and behaviour (SL and HL)
- hormones and behaviour (SL and HL)
- genetics and behaviour (SL and HL)
- the role of animal research in understanding human behaviour (HL only).

# 1 The brain and behaviour

**Topic focus**

To what extent can the structure and neurochemistry of the brain be used to explain behaviour?

## 1.1 Techniques used to study the brain in relation to behaviour

**Content focus**

Explain how different techniques can be used to study the brain in relation to behaviour.

Modern technology is now extensively used in **neuropsychology** because it provides an opportunity to study the active brain and allows researchers to see where specific brain processes take place. The choice of techniques used to correlate the brain with behaviour is based on a variety of factors, including opportunity, available technology and costs.

One of the key problems with using technology in brain research is that it can lead to reductionist arguments about the causes of behaviour that fail to consider other causes outside of biological factors. Other causes include sociocultural and socioeconomic factors, media norms, and parental and peer influences.

Furthermore, the technologies used do not provide a natural environment for **cognition**, which raises questions of **ecological validity**. The environments the active brain is studied in (with large noisy equipment) are so false and potentially

In Paper 1 (SL and HL), do not spend too long describing each technology. The key focus is whether the technological technique provides functional or structural data. You can use techniques other than the main technologies presented here (such as autopsy and the use of stroke victims) as evidence of critical thinking by showing alternative ways to investigate the brain and behaviour. You might also want to speculate as to what extent:

- reductionist arguments are valid in the human sciences
- cause and effect can be established using these techniques.

off-putting to participants that they do not necessarily give a picture of the brain in a natural environment.

Moreover, the images produced by these technologies, with their use of colours (Figure 1.2, page 4), may exaggerate the different activities of the brain.

There are two main types of imaging technology: **structural imaging** and **functional imaging**.

## 1.1.1 MRI (structural imaging)

A Magnetic Resonance Imaging (MRI) scan produces a three-dimensional picture of the brain structures. It works by detecting changes in blood flow without using a radioactive tracer. MRIs are non-**invasive** and relatively inexpensive. MRIs can measure the size of certain brain areas, which can then be compared in different groups of people. However, the images can lack clarity and precision and any conclusions are **correlational**, so **causation** cannot be inferred.

Structural imaging focuses on what parts of the brain look like in relation to each other.

### Key study: Maguire et al. (2006)

**Aim:** To investigate the extent to which the various parts of the hippocampus could be correlated with certain types of **topographical** or **spatial** memory. Topographical or spatial memory refers to the ability to recall the shape of a previously experienced environment.

**Procedure:** They compared taxi drivers with bus drivers who had similar driving experience and stress levels but differed in the sense that bus drivers follow constrained routes while taxi drivers have to constantly plan varying routes. Thirty-five healthy male volunteers participated in the study. Of these, 18 were licensed London taxi drivers and 17 were London bus drivers. Researchers used a variety of cognitive tests to match the taxi drivers and bus drivers in terms of stress and experience levels, and then gave them a structural MRI scan. Researchers then tested for functional differences between the groups in terms of their ability to acquire new **visuo-spatial** information after a 30-minute delay. They did this by asking participants to draw a reproduction of the Rey–Osterrieth Complex Figure (see Figure 1.1), which is one of the most widely used tests of spatial memory in neuropsychology.

**Findings:** They found that taxi drivers had greater matter volume in mid-posterior hippocampi and less matter volume in anterior hippocampi than bus drivers did. Furthermore, they found that years of navigation experience correlated with hippocampal matter volume only in taxi drivers, with right posterior matter volume increasing and anterior volume decreasing with more navigation experience. The ability to complete this task was worse in taxi drivers than in bus drivers.

**Conclusion:** Spatial knowledge, and not stress, driving, or self-motion, is associated with the pattern of hippocampal matter volume in taxi drivers. Maguire et al. speculate that maintaining a spatial representation of a complex object (the London road network) might require a cognitive trade-off, leading to a decreased ability to form spatial memories of new complex objects. The taxi driver's ability to navigate a complex pattern can be associated with greater posterior hippocampal grey matter volume while their lower ability to form new spatial memories can be

How would you explain the conclusion of Maguire et al. (2006) to a student who has not encountered the study before?

correlated with decreased matter volume in the anterior hippocampus. Overall, they concluded that learning, representing, and using a spatial representation of a highly complex and large-scale environment are the primary functions of the hippocampus in humans.

**In summary:** Maguire et al. (2006) were able to show that various parts of the hippocampus could be correlated with certain types of topographical or spatial memory.

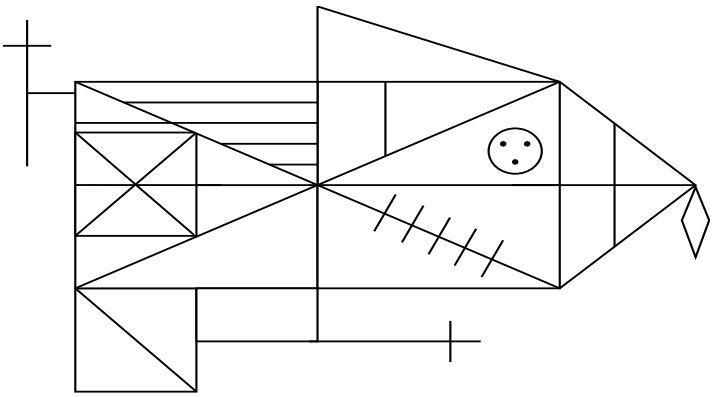

**Figure 1.1** An image of the Rey–Osterrieth Complex Figure, which is used to test spatial memory. Taxi drivers were less successful than bus drivers in recalling this figure, which was new to them, even though they were more capable of recalling routes around London, which they were familiar with.

Functional imaging focuses on how the brain works, in terms of its physiology, functional architecture and dynamics.

## 1.1.2 PET scan (functional imaging)

A Positron Emission Tomography (PET) scan monitors glucose **metabolism** in the brain. The participant is injected with a harmless dose of radioactive glucose, and the radioactive particles emitted by the glucose are detected by the PET scan. The images produced are coloured maps of brain activity, as shown below.

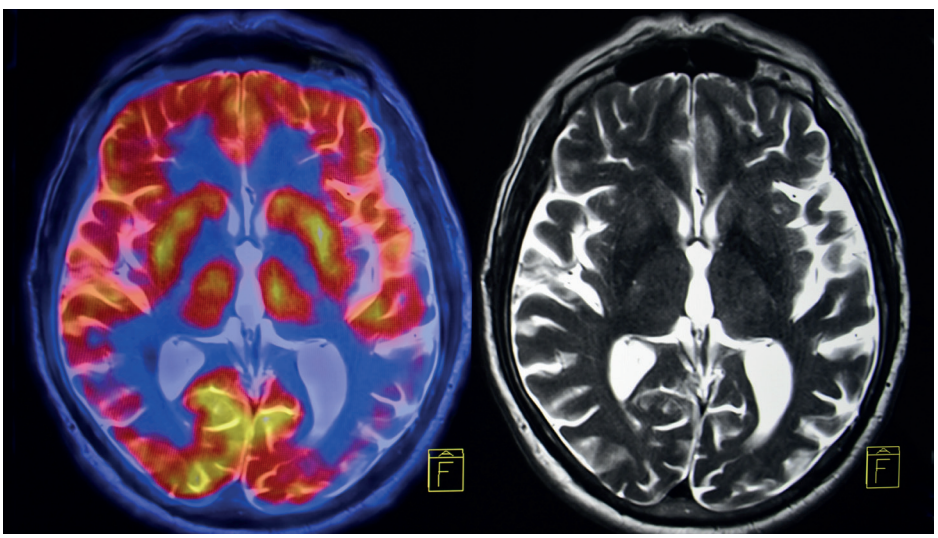

**Figure 1.2** Maps of brain activity

The PET scan has been used to compare gender difference and to investigate how the brain responds to particular stimuli. It can measure the function of certain areas of the brain by focusing on metabolic activity, which can then be compared in different groups of people.

PET scans are invasive, because the participant receives a radioactive injection, but very safe, as the radiation dose is small and goes away quickly. The greatest advantage

of PET (compared to MRI) is that it can record ongoing activity in the brain rather than produce just one static image. However, there is a high cost associated with the necessary equipment and its maintenance.

**Key study: Maguire et al. (1997)**

**Aim:** To investigate the extent to which the right hippocampus could be correlated with spatial memory.

**Procedure:** London taxi drivers were given a PET scan while they were asked to recall complex routes around London, and then while they were asked to recall famous landmarks that were not on taxi routes.

**Findings:** When participants were asked to recall complex routes around London, the right hippocampus was shown to be activated. When they were asked to recall famous landmarks of which the participants had no knowledge of the spatial location, the right hippocampus was not activated.

**Conclusion:** This suggests the right hippocampus is involved in spatial memory.

### 1.1.3 fMRI (functional imaging)

An fMRI scan studies the structure and physical functions of the brain by monitoring blood-oxygen levels. Blood-oxygen levels in the brain increase as the active parts of the brain require more oxygen.

fMRIs can record brain signals without the risks of radiation and are one of the most common brain-mapping techniques because of the relatively wide availability of the machines. Many researchers are able to access the technology, which promotes **reliability** and comparisons across studies.

The machines have high spatial resolution (up to 1 mm) and are considered more accurate than PET scans. However, they must be used carefully because they can produce false positives. Training is required and the images produced must be interpreted carefully, since brain processes are complex and often non-localized. Furthermore, the signals can be susceptible to non-neural changes in the body, such as diet.

**Key study: Eisenberger et al. (2003)**

**Aim:** To investigate the **neural correlates** of **social exclusion** and test the hypothesis that the brain bases of social pain are similar to those of physical pain.

**Procedure:** Participants were given an fMRI scan while playing a virtual ball-tossing game in which they were ultimately excluded.

**Findings:** Results showed that the anterior cingulate cortex (ACC) was more active when participants were excluded, which correlated with the results of self-reported distress. They were able to correlate these results that had also showed ACC activation during physical pain.

**Conclusion:** The social attachment system in humans may have 'piggybacked' onto the physical pain system to promote survival because it would lead to the promotion and maintenance of social bonds.

## Alternative techniques to understanding the brain and behaviour

An autopsy is a surgical procedure that examines a corpse through the process of dissection. When used in research, the main aim is to establish if specific areas of the brain can be correlated with specific thoughts, feelings and behaviour by comparing a healthy brain with any abnormalities in the brain of the deceased.

### Autopsy

An **autopsy** is a surgical procedure that examines a corpse through the process of **dissection**. It is usually performed to determine the cause of death. When applied to studying the structure and function of the brain it involves removing sections of a deceased person's brain to discover if any abnormalities can be observed.

By comparing a healthy brain to any abnormalities found in the brain of the deceased, assumptions can be made regarding which areas of the brain and which abnormalities may have been responsible for behaviour observed during an individual's lifetime.

#### Key study: Henry Molaison

An autopsy was performed on Henry Molaison (H.M.), one of the world's most famous **amnesic** patients. His amnesia was caused by an experimental brain operation carried out in 1953 to relieve his symptoms of epilepsy. H.M. died in 2008 and his brain was immediately subjected to a full autopsy. It was found to have partial damage in the medial temporal stem and in particular the parahippocampal cortex, which is an area of the brain that surrounds the hippocampus. The results confirmed these areas play an important role in memory encoding and retrieval (Augustinack et al. 2014) because these were the specific problems H.M. had during his lifetime.

Researchers can also use scanning techniques on portions of brain that are removed. For example, Augustinack et al. (2014) used high-resolution MRI imaging on parts of H.M.'s brain and were able to distinguish between the age-related white matter disease that likely accounted for the dementia he suffered in the final part of his life and the damage caused by the surgery when he was a younger man. By using methodological **triangulation** they were able to add validity to their findings and suggest definitive connections between brain areas and specific behaviours.

Use examples to support any assertions about functional localization. Ask:

- To what extent are reductionist arguments valid in the human sciences?
- To what extent can cause and effect be established using the assumptions of localization?

## 1.2 Localization

**Content focus**

Explain localization while addressing the limitations of this model.

### 1.2.1 Defining localization

**Localization** refers to the notion that specific areas of the brain are responsible for specific behaviours. It assumes that specific areas can be correlated with specific thoughts, feelings and behaviour.

Studies that show clear localization in the previous pages include:

- Maguire et al. (1997, 2006) investigated to what extent the right hippocampus could be correlated with spatial memory. They used a PET scans and MRI scans over a number of studies and concluded that the right hippocampus is involved in spatial memory as it is more active in spatial tasks and becomes enlarged over time with individuals who are engaged in intense spatial awareness tasks.
- Eisenberger et al. (2003) investigated the neural correlates of social exclusion with fMRIs and tested the hypothesis that the brain bases of social pain are similar to those of physical pain. They concluded that the anterior cingulate cortex (ACC) was involved in feelings of social exclusion.

## Key study: Raine et al. (1997)

**Aim:** To compare specific brain structures in murderers and non-murderers. The researchers measured brain activity to investigate whether there was dysfunction of the same areas in both groups.

**Procedure:** The 'murderers' were 41 prisoners (39 male, two female) with a mean age of 34.3 years, who had been charged with murder or manslaughter in California, USA.
Participants had been referred for brain imaging scans to obtain evidence or information relating to either a defence of not guilty by reason of **insanity**, incompetence to stand trial, or proof of diminished capacity that could reduce the sentencing after being found guilty.
A **matched-pairs** design was used where each murderer was matched with a 'normal' subject – a control – for age, sex and diagnosis of **schizophrenia** where necessary. Each match was screened to exclude physical and mental illness, history of drug use and a history of murder. Therefore, the variable of 'murder' had been isolated.
No subject took psychoactive medication for two weeks before scanning, to prevent medication affecting the results.
After practice trials, all participants were injected with a tracer substance (fluorodeoxyglucose) that was taken up by the brain to show the location of brain metabolism while conducting a continuous performance task (CPT). A PET scan was then immediately given to show the relative brain activity for **cortical** areas (on the outside of the brain) and **subcortical** areas (inside the brain).

**Findings:** A summary of results from Raine et al. (1997).

| Brain structure | Murderers' metabolic activity level | Interpretation |
|---|---|---|
| Prefrontal cortex | Lower activity in murderers than in controls. | Linked to loss of self-control and altered emotion/linked to emotional control. |

TOK

To what extent does the concept of localization (reducing complex behaviours to specific brain regions) help and hinder understanding of human thoughts, feelings and behaviour?

Localization refers to the notion that specific areas of the brain are responsible for specific behaviours. It assumes specific areas can be correlated with specific thoughts, feelings and behaviour.

| Brain structure | Murderers' metabolic activity level | Interpretation |
|---|---|---|
| Parietal cortex | Lower activity in murderers than in controls especially in the left angular and bilateral superior gyrus. | Lower left angular gyrus activity linked to lower verbal ability and therefore possibly educational failure/certain levels of frustration at not being able to express themselves – possibly crime. |
| Amygdala | Lower activity in left than right side of the brain in murderers than in controls. | These structures form part of the limbic system (thought to control emotional expression). Problems with these structures may cause a lack of inhibition for violent behaviour, fearlessness and a failure to learn the negative effects of violence. |

**Conclusion:** Raine et al. demonstrate a clear physiological difference between violent people and non-violent people. The study also shows specific localized brain areas that can be linked with an extreme behaviour such as murder.
The study has many strengths, including gender balance. Although the number of females was low, violent murder is a crime committed more often by men.
Ethically this study was very well conducted, as permission was sought and granted from the relevant authorities and no intrusive techniques were used.
Methodologically this is a relatively large sample given the cost of PET scans. There was also a clear use of controls to rule out alternative effects on brain activity. Moreover, the effort put into the matched-pairs design is a strength.
The study has some weaknesses, notably the use of PET scans, which can lack precision. Furthermore, the findings apply only to a small subgroup of violent offenders and they were not a **homogenous** group. Some were murderers and some were manslaughterers, and the reasons for their scanning referrals were very diverse, ranging from schizophrenia (six cases) to head injury or organic brain damage (23 cases). Therefore the majority of cases had some kind of brain injury, which limits the generalizability of the results to a wider, non-brain-damaged population.
Extreme caution should be used when correlating specific areas of the brain with specific behaviours, as it may be the damage to the brain that causes those behaviours.

## 1.2.2 Limitations of localization

Localization can cause errors in analysis.

There is a significant variability in brain anatomy between individuals caused both by **genetic** predisposition and **neuroplasticity** (discussed in section 1.3).

Studies in localization can lead to reductionist arguments for behaviour causation whereby specific behaviours are linked with specific areas of the brain and it is then assumed those areas cause the behaviour. However, because of the processes involved in individual variability and neuroplasticity, a clear causative relationship between location and function can rarely be inferred. Reducing complex behaviours to purely

biological factors is tempting for researchers because it ignores factors that are difficult to study, such as the intertwined relationship of sociocultural and cognitive processes, as well as individual responsibility. For example, Raine et al. focus on specific brain areas and assume these are linked to specific behaviours. However, their findings do not mean violence is caused by biology alone as other social, psychological and situational factors are involved in such an extreme and complex behaviour. Moreover, the findings do not demonstrate the murderers are not responsible for their actions and they do not mean PET scans can diagnose murderers. The findings do not reveal whether the brain abnormalities are a cause or effect of behaviour.

The brain is a complex organ; its structure is only just being uncovered. While scanning is an important tool in uncovering localization – as it shows a link between activation and a specific task or behaviour – it is often difficult to identify the area to which the activation corresponds because of poor image quality and the complexity of the area in question. Researchers are only just beginning to standardize parcellations of the brain in terms of function, microanatomy and labelling, although this will increase as technology becomes more accurate.

To some extent, brain locations are human constructions that are not present in actuality because the brain is a highly interconnected organ. There is considerable disagreement as to where certain locations start and end. Different theorists using different technologies often question and redraw boundaries depending on the task and technology used.

Researchers have resorted to two main approaches to solve this problem:

- labelling brain locations through coordinates, usually in relation to the Talairach coordinate system
- labelling through names usually in relation to the accepted anatomic labels of brain locations.

Both systems produce inaccuracies because of the lack of task and equipment standardization. A coordinate is often the most useful label for comparison with other results in neuro-imaging, but it can be difficult to compare coordinates with brain locations obtained from other types of data.

Furthermore, as labels and coordinates become embedded in research conclusions, they become more accepted over time and create a rigidity of understanding for other researchers to base their studies and results on. Such rigidity has advantages, as it produces a basis of understanding, but it could also mean that researchers are more likely to ignore results that do not correlate with established understanding of localizations of function.

TOK How can we determine whether the regions of the brain occur in actuality or are just products of the human research process?

EE To what extent can a specific behaviour be explained by localization?

## 1.3 Neuroplasticity

**Content focus**

Explain how neuroplasticity is influenced by both genes and the environment.

Neuroplasticity refers to how the brain changes over time as a result of environmental influences. It can also be referred to as brain plasticity, cortical plasticity or cortical remapping.

Neuroplasticity refers to how the brain changes over time as a result of environmental influences. It can also be referred to as brain plasticity, cortical plasticity or cortical remapping.

Make a clear link between the effect on brain development and environmental stimuli. Clearly label the environmental stimuli throughout your answer. Distinguish between human and animal research.

Although genes provide the basic outline for brain development, environmental influences shape gene expression in the brain through the process of neuroplasticity. Neural networks can change as a result of sociocultural and personal experiences or as a result of brain injury.

**Genotype** refers to the genetic constitution of an individual organism.

**Phenotype** refers to the set of observable characteristics of an individual that is a result of the interaction between the genotype and its environment.

A phenotype results from the expression of an organism's genotype and the influence of environmental factors as well as interactions between the two. A single genotype can be expressed in a multiplicity of distinct physiological and behavioural phenotypes.

The field of research that studies the interaction between genetic determinability and environmental interaction has been termed **psychosocial genomics** (Rossi, 2002). Psychosocial genomics is an interdisciplinary study of the processes by which gene expressions are modulated by psychological and sociocultural and personal experiences.

It is an interdisciplinary approach because the union of neuroplasticity and psychosocial genomics research represents a synthesis of the social and biological sciences that is non-reductive: it does not dismiss human experience as the product of a neural machine or predetermined genetic blueprint. Instead, such an approach is integrative, inclusive, and holistic (Garland and Howard, 2009).

The brain structure is highly **heritable**, but the extent of heritability remains open to debate.

### Key study: Watanabe et al. (2016)

**Aim:** To investigate how genetics and environmental factors influence the brain.

**Procedure:** They used PET scans to measure glucose metabolism in 40 pairs of monozygotic (identical) twins and 18 pairs of dizygotic (fraternal) twins. They assumed any differences in glucose metabolism between monozygotic twins could be attributed to environmental factors, since they are genetically identical. Therefore, when a genetic influence is dominant, the monozygotic twins would have more trait similarity than the dizygotic twins. When an environmental influence is dominant, the trait similarity would be the same for identical and fraternal twins.

**Findings:** Both genetic and environmental factors influenced glucose metabolism in the brain, but different parts of the brain were influenced by genetic or environmental factors to differing degrees. For example, genetic influences were found to play a significant role in the left and right parietal lobes where sensory information such as taste, temperature and touch are processed. Genetic influences were also found to play a significant role in the left temporal lobe where sounds and speech comprehension are processed.

**Conclusion:** More research is needed to ascertain why certain areas of the brain are more open to influence from genetic or environmental factors, but it seems reasonable to conclude that the regions of the brain that are shaped more by environmental forces will be more susceptible to neuroplasticity.

TOK

To what extent do interdisciplinary approaches help or hinder knowledge creation?

The causes of neuroplasticity are difficult to research conclusively in humans because of the highly varied nature of the environment and the early stages of genetic research into the phenomena.

However, neuroplasticity has been well documented in animal studies. For example, Rosenzweig and Bennett (1972) demonstrated the effect of a physically enriched environment on the thickness of the **frontal lobe** in rats. The enriched, stimulating environment was characterized by interesting toys to play with while the deprived environment was operationalized by no toys. The rats spent 30 or 60 days in their respective environments and then they were euthanized. The post-mortem studies of their brains showed those that had been in the stimulating environment had an increased thickness in the frontal lobe, which is associated with thinking, planning, and decision making. Similar research studies demonstrated how cortical thickness increases even further if rats are placed with other rats.

The experimental nature of the study, with a clear independent variable (IV) and dependent vaariable (DV), allows causation to be inferred. However, this is an animal study and caution should be used when generalizing the results to humans. The manipulation of an environmental IV to measure the impact on a physiological DV would be not possible on humans for ethical reasons.

Isolating key variables and then documenting the effect on brain growth is challenging from a research standpoint because of these **ethical considerations** and the unpredictability of environmental factors. However, it is possible through careful isolation and measurement.

### Key study: Luby et al. (2012)

**Aim:** To investigate the effect of **nurturing** mothers on the hippocampal development of their children by isolating the variables of nurturing and hippocampal development.

**Procedure:** The researchers used 92 children aged between 3 and 6 years old in a longitudinal study. Because of ethical considerations, researchers cannot deliberately create a non-nurturing environment and then measure the effect on brain development, so Luby et al. used a **natural experimental** method and pre-determined which parents were nurturing and which were non-nurturing.
The children were put into a frustrating situation whereby they and their mothers were left in a room with a brightly wrapped package. The children were not allowed to open the gift and they were told to wait while the mother filled out a series of forms. The researchers observed how the children and mothers handled this situation, which was meant to replicate the typical stressors of daily parenting. Mothers who offered reassurance and support that helped their child control their impulses were rated as being nurturing. Mothers who either ignored the child or harshly scolded the child were rated as non-nurturing.
When the children were between 7 and 10 years old, Luby et al. performed MRI brain scans on them.

**Findings:** The children with the nurturing mothers had a hippocampus that was 10 per cent larger than the hippocampi of children with non-nurturing mothers.

**Conclusion:** A nurturing environment impacts children's brain development.

**In summary:** Luby et al. (2012) used a natural experimental method to measure the effect of non-nurturing environments on hippocampal growth in children. They found that children from non-nurturing environments had a smaller hippocampus than children from nurturing environments.
The study highlights the positive relationship between early experiences of maternal nurturing and hippocampal volume. However, the key failing of any study that cannot account for extraneous variables is that it is difficult to pinpoint which aspects of parental nurturing cause the effect in the hippocampal volume. Non-nurturing is a very broad concept and encompasses many behaviours. For example, non-nurturing mothers may also neglect to feed their children healthily, or read to them regularly, both of which may also impact their children's brain development.

Maguire et al. (2006) were able to isolate the variables of complex navigational experience and hippocampal development by comparing taxi drivers with bus drivers. The isolation of these variables occurred by splitting them into two distinct groups: taxi drivers and bus drivers. Bus drivers follow constrained routes while taxi drivers had to constantly plan varying routes. They then used a variety of cognitive tests to match the drivers in terms of stress levels and driving experience and then gave them a structural MRI scan.

They found that taxi drivers had greater matter volume in mid-posterior hippocampi and less volume in anterior hippocampi. The years of navigation experience correlated with hippocampal matter volume in the taxi drivers, with right posterior matter volume increasing and anterior volume decreasing with more navigation experience. Maguire et al. (2006) were able to cautiously suggest this was an example of neuroplasticity in action, as the taxi drivers' constant need to use complex spatial memory had meant a development of the mid-posterior hippocampi.

Gilles et al. (1996) aimed to create an animal model to show the effects of continuous **chronic** stress on **corticosterone** secretion in response to an **acute environmental stressor**.

Previous studies had used an absence of the mother to induce stress but the researchers wanted a model that could be comparable with human experiences. Therefore, stress was moderated by placing newborn rats into an environment with their mothers that featured either good or limited bedding before they were euthanized and their bodies subjected to an autopsy.

The group with limited bedding manifested increased corticosterone. Gilles et al. were able to suggest the experiences they had created in the laboratory were approximate to the human situation of chronically stressed, neglected infants.

The research is important because corticosterone secretion has a profound effect on the structure, development and function of the hippocampus particularly via **dendritic retraction** – a form of neuroplasticity. Dendritic retraction involves reductions in dendritic length and reduced branch numbers, and has traditionally corresponded to hippocampus-dependent spatial memory deficits (Conrad, 2006), further suggesting the hippocampus is involved in spatial memory.

Other studies have shown the effects of environmental stress on the development of the hippocampus can be reversed when maternal care is reintroduced, which again shows that environmental change can cause neuroplasticity (Edwards and Burnham, 2001).

## 1.4 Neurotransmitters and their effect on behaviour

### Content focus

Explain how neurotransmitters cause behaviour through agonistic and antagonistic mechanisms and comment on to what extent cause and effect can be inferred.

The nervous system is comprised of **neurons** (nerve cells) and they are one of the building blocks of behaviour. Neurons send electrochemical messages to the brain so that people can respond to stimuli – either from the environment or from internal changes in the body.

The method by which these messages are sent is called **neurotransmission**. When an electrical impulse travels down the axon (the body) of the neuron, it releases neurotransmitters, which then cross the gap between two neurons. This gap is called a synapse.

The neurotransmitters are stored in the neurons' terminal buttons. After crossing the synapse, the neurotransmitters fit into receptor sites on the post-synaptic membrane. Once the message is passed on, the neurotransmitters are either broken down or reabsorbed.

Neurotransmitters are affected by **agonists**, which amplify their effect, and **antagonists**, which reduce their effect. Neurons working together can produce a large variety of effects resulting in a complex repertoire of thoughts, feelings and behaviours. Neurotransmitters also have different effects in different systems in the human body. For example, **acetylcholine (ACh)** is involved in muscle contraction when it acts on motor neurons, but is involved in memory in the hippocampus. Therefore, the complexity of these chemical interactions, together with the range of effects, makes cause–effect difficult to establish.

Neurotransmitters are involved in a range of thoughts, feelings and behaviours.

| Neurotransmitter | Some effects |
|---|---|
| ACh | Muscle contraction and memory |
| Dopamine | Voluntary movement, learning, and feelings of pleasure |
| Norepinephrine (noradrenaline) | Arousal, alertness, and stimulation |
| Serotonin | Sleep, arousal levels, and emotion |

Speculate as to what extent a cause-effect relationship can be inferred regarding neurotransmitters and their effects.

- Critique the studies, but remember all methodologies have flaws and always consider to what extent these flaws undermine the entire validity of the conclusion.
- Avoid coming to definitive conclusions about specific hormones. Instead, come to cautious conclusions based on the findings of varied research.
- Use animal studies to show how the manipulations of certain variables can be carried out on animals, but not humans, and thereby demonstrate cause and effect. Caution should be used if generalizing the findings of animal studies to humans.

Neurotransmitters are the body's natural chemical messengers, they transmit information from one neuron to another across the synapse.

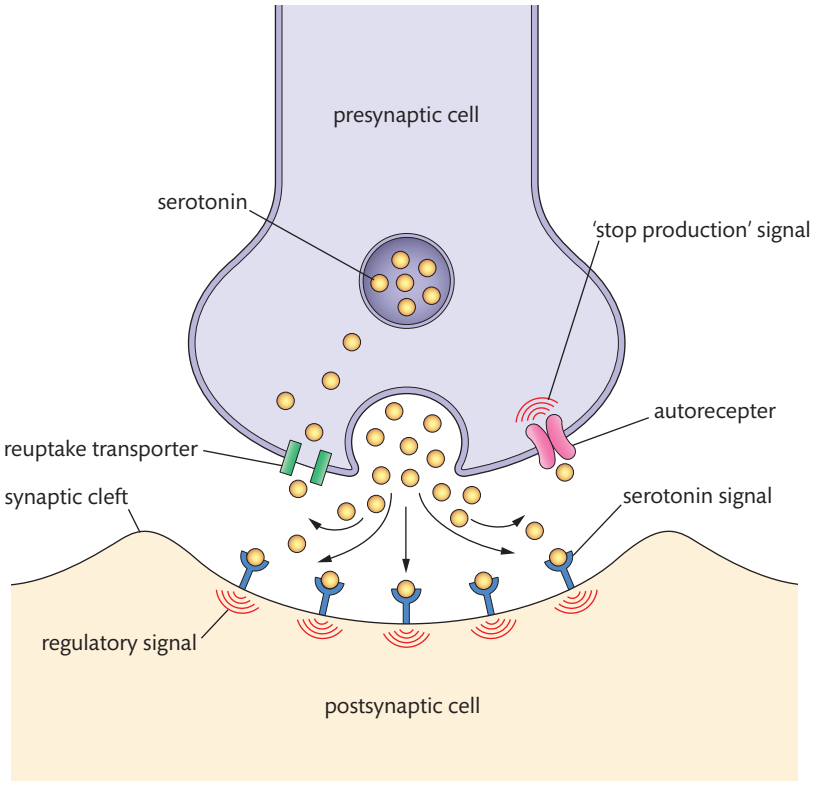


**Figure 1.3** Synaptic transmission

An agonist is a chemical that binds to a receptor and activates it to provoke a biological response.

An antagonist is a chemical that binds to a receptor and blocks it to dampen a biological response (they are sometimes called blockers).

The complexity of these chemical interactions makes cause–effect difficult to establish, but researchers can use agonists and antagonists to manipulate the levels and effects of neurotransmitters.

## 1.4.1 Acetylcholine

The main role of ACh is to change the state of neuronal networks throughout the brain and modify their response to internal and external stimuli. The diverse effects of ACh depend on the site of release and the receptor subtypes. However, a common theme is that it has a role in behaviours that are **adaptive** to environmental stimuli as well as decreasing responses to stimuli that do not require immediate action (Picciotto et al. 2012). ACh is also thought to play a role in memory formation.

### Key study: Martinez and Kesner (1991)

**Aim:** To investigate the role of ACh in learning and memory.

**Procedure:** Rats were trained to go through a maze at the end of which they received food. Once the rats were able to do this, they injected one group of rats with an antagonist substance (scopolamine) that blocks ACh receptor sites, thus decreasing available ACh. They then injected a second group of rats with an agonist (physostigmine) that led to the increase of ACh and stopped the synapse returning to its 'resting state'. A third group, the control group, were not given any injections. Therefore, the researchers either boosted or blocked levels of ACh in two groups of rats. The dependent variable (DV) was memory, measured by how fast the rats could run a maze.

**Findings:** The rats that had their ACh levels boosted were better at running the maze and they found the food more quickly.

**Conclusion:** The researchers concluded that ACh played an important role in creating a memory of the maze.

**Criticism:** This study has a clear IV (levels of ACh) and a clear DV (ability and time taken to run the maze), so the use of an experimental method with a control group makes it possible to establish a **cause-and-effect relationship** between levels of ACh and memory. However, the limitation of the research is that it is questionable to what extent these findings can be generalized to humans, but human research has shown that ACh-producing cells in the basal forebrain are damaged in the early stages of Alzheimer's disease, which suggests that ACh does have a role to play in memory formation in humans.
The nervous system involves complex interactions, making clear cause-effect with isolated variables difficult to establish. Experimental evidence suggests that memory processing is mediated by parallel, and to some extent independent, neural systems. Because different memory systems appear to acquire different classes of information, the processing of different attributes of memory may at times come into conflict with one another (White and McDonald, 2002). Therefore, while experimentation through manipulation of clear **independent variables** to measure the effect on clear **dependent variables** makes researchers confident they can claim cause-effect, it is essential that caution is used when coming to conclusions. While Martinez and Kesner appear to show a clear link between spatial memory formation and ACh in this study, researchers cannot simply conclude ACh increases memory.

The complexity of brain functionality means that researchers must be very cautious when claiming simple cause-effect relationships between neurotransmitters and specific responses.

McIntyre et al. (2002) suggest ACh release may reflect activation and participation of the hippocampus in learning and memory, but in a manner that can be detrimental to performance on another brain area such as the **amygdala**, which is also involved in memory. They were able to measure ACh levels in rat hippocampi. When the levels were high in the hippocampus the rats were more able to perform spontaneous spatial awareness tasks but less able to perform tasks needing conditioned responses, which are associated with the amygdala.

They concluded that ACh can be linked with certain brain areas, such as the hippocampus, which are themselves responsible for certain types of memory, but high levels may impair other functions that require a different type of memory.

## 1.4.2 Serotonin

Like ACh, **serotonin** has a number of roles and performs differently in different parts of the body where it exists in varying amounts. In most humans, serotonin is found in the digestive tract where it regulates food digestion. A small amount is found in the central nervous system (CNS) where it is involved in mood regulation, appetite, and sleep, as well as cognitive functions such as learning and memory. Again, this means researchers need to be cautious in claiming any single cause-effect relationship.

'Falling in love' is deeply intertwined with feelings and emotions, and humans expend energy and devote resources to the person they fall in love with. Therefore, researchers assume the **evolutionary** consequences of love are so important that there must be some long-established biological mechanism that regulates and promotes it. For

example, it has been noted that in the early stages of love, the object of love becomes an overvalued idea, similar to the thought processes of someone suffering from **obsessive compulsive disorder (OCD)**. Research has pointed to the possibility that the two conditions, love and OCD, might share some physiological similarities.

### Key study: Marazziti et al. (1999)

**Aim:** To test whether the obsessional nature of early phase love might share the same physiological basis as obsessive compulsive disorder (OCD), which has a similar psychological framework of obsessiveness.

**Procedure:** Twenty subjects who had fallen in love within the previous six months were compared with 20 non-medicated OCD patients and 20 controls. The density of the platelet 5-HT transporter was measured – a low measurement would indicate a low level of serotonin.

**Findings:** The main finding of the study was that subjects who were in the early romantic phase of a love relationship were no different from OCD patients in terms of the low density level of the platelet 5-HT and both groups had significantly lower levels than in the normal controls.

**Conclusion:** Love and OCD were physiologically similar and serotonin could act as a biological mechanism to explain 'falling in love' and pair-bonding behaviour.

**Criticism:** This was a correlational study, so caution should be used when assuming low levels of serotonin caused either OCD or 'in-love'-type behaviour because the low serotonin levels may be the consequence of the in love and OCD behaviour rather than the cause of it. Moreover, the sample group was small and should be seen more as a pilot study rather than a definitive account of the effects of serotonin.

TOK

To what extent does the process of reducing complex behaviour to biological mechanisms help or hinder knowledge creation?

How does the language in the phrase 'falling in love' impart meaning about this process? Do other languages use similar metaphors?

There has been a philosophical criticism of reducing the explanation of a complex behaviour such as falling in love to the workings of neurotransmitters alone. Given the complexity of the thoughts, feelings and behaviour of falling in love, it is likely that more than one chemical interaction is involved. It should also be considered that neurotransmitters have different effects in different regions. For example, it is possible that serotonin, rather than activating a region associated with pair bonding, actually deactivates a region associated with negative emotions, social judgement, and 'mentalizing' that is, the cognitive assessment of other people's intentions and emotions (Zeki, 2007), thereby allowing falling in love to take place.

The lack of cause-effect inference from certain studies can be addressed by experimental manipulation of variables. This is challenging with humans and must be carefully considered.

### Key study: Passamonti et al. (2012)

**Aim:** To manipulate serotonin levels through diet with an aim to measure the effects via an fMRI scan of the participants' brains. As well as 'falling in love', reduced serotonin levels have also been implicated in aggression and therefore, Passamonti et al. wanted to test if such overt manipulation produced an effect.

**Procedure:** They used **tryptophan**, which can be used as a serotonin agonist; its presence increases the effects of serotonin. Thirty healthy volunteers' serotonin levels were manipulated by giving them a mixture of amino acids that lacked tryptophan, which is a building block for serotonin, on the experimental day, and the same mixture but with a normal amount of tryptophan on the placebo day. On the experimental day, they were artificially having their serotonin levels lowered. Passamonti et al. then used a personality questionnaire to generate **quantitative** data associated with personality characteristics. They were able to determine which individuals had a natural tendency to behave aggressively.
All participants were then scanned using an fMRI as they viewed faces with angry, sad, and neutral expressions. Using the fMRI, researchers were able to measure how different brain regions reacted and communicated with one another when the volunteers viewed the different faces.

**Findings:** The research showed that low brain serotonin levels inhibited communication between the amygdala and the frontal lobes compared to communication present under normal levels of serotonin.

**Conclusion:** The amygdala is thought to be associated with generating emotional reactions and the frontal lobe is thought to be associated with regulating them. Therefore, the findings suggest that when serotonin levels are low, it may be more difficult for the forces of the prefrontal cortex to control the emotional responses to anger that are generated within the amygdala.
In individuals determined to have a natural tendency toward agression, the communications between the amygdala and the prefrontal cortex was even weaker following serotonin depletion. This finding suggests those individuals who might be predisposed to aggression were the most sensitive to low levels of serotonin. These results also support the localization data from Raine et al. (1997) who found lower activity of the frontal lobe in murderers when compared to controls.

EE To what extent can a specific neurotransmitter be used to explain a specific behaviour?

Speculate as to what extent a cause-effect relationship can be inferred regarding hormones and their effects.

- Critique the studies. All methodologies have flaws so consider to what extent these flaws undermine the conclusion's validity.
- Avoid definitive conclusions about specific hormones. Instead, make cautious conclusions based on the findings of varied research.
- Use animal studies to show how the manipulations of certain variables can be carried out on animals, but not humans, and thereby demonstrate cause-effect. Caution should be used in generalizing the findings of animal studies to humans.

# 2 Hormones and pheromones and behaviour

**Topic focus**

To what extent can hormones be used to explain behaviour?

## 2.1 Hormones and behaviour

**Content focus**

Explain how hormones cause changes in thoughts (attention), feelings (mood), and behaviour.

Hormones are chemicals released by specific **glands** in the body to regulate medium- and long-term behaviour changes. However, some hormones (e.g. adrenaline) also act as **neurotransmitters** and can produce more instantaneous effects on mood and attention.

Hormones are chemicals released by specific glands in the body to regulate medium- and long-term behaviour changes. However, some hormones (e.g. adrenaline) also act as neurotransmitters and can produce more instantaneous effects on mood and attention.

Hormones are involved in a range of thoughts, feelings and behaviours.

| Hormone | Gland(s) | Function |
|---|---|---|
| Adrenaline | Adrenals | Flight or fight response, arousal |
| Cortisol | Adrenals | Arousal, stress, memory |
| Oxytocin | Pituitary and hypothalamus | Social recognition via facial expression, mother–child attachment, and attachment |
| Testosterone | Gonads | Development, social status via aggression |

Hormones enter the bloodstream and they take longer to produce changes in behaviour than neurotransmitters.

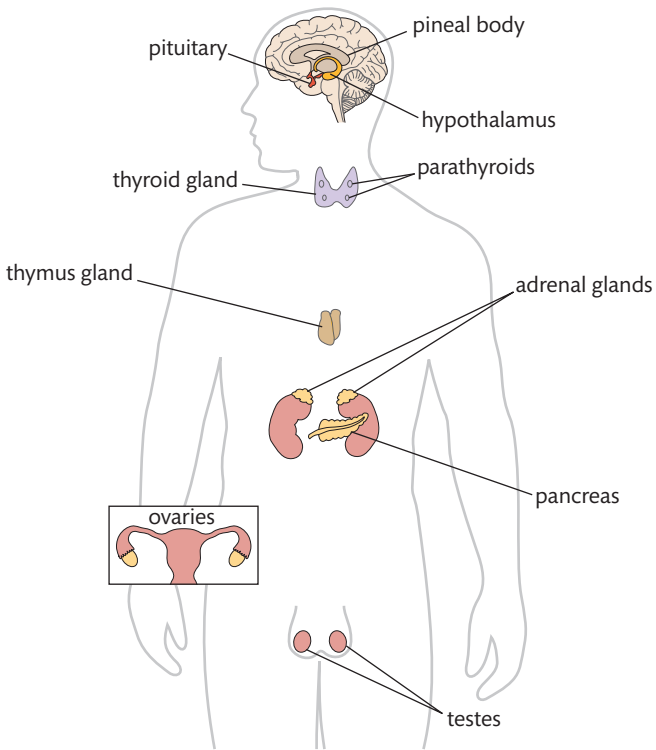


**Figure 2.1** The glands that produce hormones make up the endocrine system.

## 2.1.1 Oxytocin

Oxytocin is a hormone that is produced by the hypothalamus after being stimulated by the pituitary gland. Oxytocin release is often triggered by touches and hugs and it is associated with bonding between lovers, and mothers and offspring, as well as wider social emotions.

Oxytocin appears to change the brain signals related to social recognition via facial expression, perhaps by changing the firing of the neurons of the amygdala. This is the part of the brain that plays an important role in processing emotional stimuli.

Does ethical and non-ethical behaviour depend on free will? Can the concept of free will in human behaviour be measured?

If oxytocin is given to healthy individuals it seems there is an increase in feelings of trust and generosity. The inability to secrete oxytocin and feel empathy has been linked to psychopathic behaviour, which is a disorder characterized by shallow feelings, a lack of guilt, and showing superficial charm and criminality as well an increase in feelings and behaviour associated with **narcissism**.

## Key study: Guastella et al. (2008)

**Aim:** To measure the effects of **oxytocin** on male humans and how it enhances the **encoding** of positive social information.

**Procedure:** Oxytocin or a placebo was given in the form of a nasal spray to 69 healthy male volunteers. They were then presented with 36 happy, angry, or neutral human faces. Participants returned the following day to make 'remember' and 'know' judgements for a mixture of 72 new and previously seen faces.

**Findings:** Oxytocin-administered participants were more likely to make 'remember' and 'know' judgments for previously seen happy faces compared with angry and neutral human faces. In contrast, oxytocin did not influence judgements for faces that had not been presented previously.

**Conclusion:** The administration of oxytocin to male humans enhances the encoding of positive social information to make it more memorable. The results suggest that oxytocin could enhance intimacy and bonding in humans by strengthening encoding to make the recall of positive social information more likely. The study used only male participants, therefore caution should be used when generalizing the results to females.

It would be inaccurate to describe oxytocin as a 'pro-social' hormone, because human interaction is complex. For example, a study showing the 'negative' social effects of oxytocin was conducted by Shamay-Tsoory et al. (2009), who aimed to measure the effect of oxytocin on envy and schadenfreude (enjoyment over others' misfortune).

Oxytocin should not be simply described as a 'pro-social' hormone as human interaction is too complex. It is thought to be involved in envy and schadenfreude.

The researchers argued that humans have a strong social tendency to compare themselves with others and they tend to feel envious when they receive less valuable rewards. They also tend to rejoice when their own payoffs are more advantageous. Envy and schadenfreude are social feelings widely agreed to be a symptom of the human social tendency to compare one's payoffs with those of others.

Shamay-Tsoory et al. speculated that oxytocin may have a moderating effect on the intensity of these emotions. Fifty-six participants were either given nasal doses of oxytocin or a placebo. They then played a game of chance with another (fake) participant who either won more money (envy manipulation), lost more money (schadenfreude manipulation), or won/lost equal amounts of money. In comparison with the placebo, oxytocin increased the envy ratings during unequal monetary gain conditions. Oxytocin also increased the ratings of schadenfreude during gain conditions. However, oxytocin appeared to have no effect on the emotional ratings following equal monetary gains and did not affect general mood ratings. Therefore, this study shows oxytocin is involved in moderating envy and schadenfreude and not just 'positive' pro-social behaviours.

## Key study: Guastella et al. (2010)

**Aim:** To measure the effects of oxytocin on the Reading the Mind in the Eyes Task, which is a widely used and reliable test of emotion recognition. It involves participants being shown a picture of eyes and asked to discern what emotion they are showing.

**Procedure:** In a **double-blind**, **randomized**, **placebo**-controlled design, oxytocin nasal spray or a placebo was administered to 16 males aged 12 to 19 who had been diagnosed with **autistic** or **Asperger's** disorders. Participants then completed the Reading the Mind in the Eyes Task.

An example of the Reading the Mind in the Eyes Task.

**Findings:** In comparison with placebo, the results showed that oxytocin administration improved performance on the Reading the Mind in the Eyes Task. This effect was also shown when analysis was restricted to the younger participants, aged 12 to 15, who received a lower dose.

**Conclusion:** Oxytocin is linked to perception of emotions and the study provides the first evidence that oxytocin nasal spray improves emotion recognition in young people diagnosed with autism spectrum disorders (ASD). Findings suggest the potential of earlier intervention and further evaluation of oxytocin nasal spray as a treatment to improve social communication and interaction in young people with these disorders.

**In summary:** Although oxytocin has been called 'the love hormone' because it seems to be involved in pro-social behaviour such as bonding and remembering positive faces, it is more accurate to call it the 'pleasure hormone' as it is also involved with more negative social emotions such as envy and schadenfreude. The term 'love hormone' is too simplistic when the pleasure induced comes from the misfortune of others.
Furthermore, oxytocin appears to be closely linked with improved emotional recognition and provides insight into male-dominated disorders such as ASD. A strong male bias in ASD prevalence has been observed with striking consistency, with a male to female ratio of 4:1 (Werling and Geschwind, 2013). No mechanism has been identified to account for this gender difference, and oxytocin may provide an avenue of future investigation.

## 2.1.2 Testosterone

**Testosterone** is a **steroid** hormone from the androgen group. In mammals, testosterone is primarily secreted in the testes of males and the ovaries of females, although small amounts are also secreted by the **adrenal glands**. It is the principal male sex hormone. In men, testosterone plays a key role in health and well-being. A typical adult human male produces about 40–60 times more testosterone than an

adult human female, but females are, from a behavioural perspective (rather than from an anatomical or biological perspective), more sensitive to the hormone.

Wagner et al. (1979) measured the effects of reduced levels of testosterone on aggression in male mice. They used a clear experimental method with the manipulation of the independent variable (IV) to measure an effect on a dependent variable (DV). The IV was the level of testosterone, **operationalized** by the mice being first castrated and then injected with testosterone. The DV was levels of aggression, operationalized by the number of bites exhibited. They found castration reduces aggression and then testosterone restores aggression in castrated mice who were previously judged to be aggressive. When the injections ceased, it led to reduced levels of aggression again.

Therefore, while there is a **causal** link between aggression and testosterone, caution should be used when inferring a unitary **causal relationship**. Methodologically this is a very tightly controlled study with a clear IV (testosterone) and a clear, quantifiable DV (number of bites exhibited). However, caution should always be used when **generalizing** the results of animal studies to humans.

### Key study: Dreher et al. (2016)

**Aim:** To test whether testosterone can increase status-relevant aggressive behaviours, such as responses to provocation, while also being linked to status-relevant non-aggressive behaviours, such as feelings of generosity toward others.

**Procedure:** Forty healthy young human males were injected with testosterone or a placebo in a double-blind randomized design. Therefore, neither the participants nor the experimenter knew which participants were the experimental group or the placebo group.
Participants played a version of the Ultimatum Game (UG), a game in which two players must decide how to split a sum of money between them. In each round, the first player (the proposer) presents a proposal to the second player (the responder), which describes how this money should be divided. The responder accepts this proposal and the split is implemented, or rejects it and both players win nothing. The game was modified so that the participants who played the role of the responder, having accepted or rejected a proposed split, had the option to reward or punish the proposer by increasing or decreasing their monetary payoff at a proportional cost to themselves. Therefore, it was a game of risk that allowed participants to reward and punish the proposer.

**Findings:** The results showed participants treated with testosterone were more likely to punish the proposer and that higher testosterone levels were associated with increased punishment of proposers who were deemed to make unfair offers. This supports the long-held assumption that testosterone can be linked with aggressive responses to provocation. When participants who had been administered with testosterone received large offers, they were more likely to reward the proposer and also chose rewards of greater magnitude.

**Conclusion:** This increased generosity in the absence of provocation indicates that testosterone can also be linked with pro-social behaviours that are appropriate for increasing status.

Research undermines the simple causal link between testosterone and male aggression. Instead, testosterone's effect on male behaviour depends on the social context in which it occurs and is more likely linked to social status rather than simply aggression.

Dreher et al. suggest that testosterone, by playing on both positive and negative incentives, could have played a key evolutionary role by not only promoting aggressive behaviour but also increasing feelings of generosity, which leads to more generous behaviour and in turn a higher social status. They note how observations in non-human primates also indicate that the social hierarchy may be maintained by alpha males who have higher testosterone levels by not only aggressive behaviour but also sharing resources, such as access to food and females (Czoty et al., 2009). The findings undermine the notion of a simple causal link between testosterone and male aggression. Instead, testosterone's effect on male behaviour depends on the social context in which it occurs.

### Key study: Gettler et al. (2011)

**Aim:** To determine whether fatherhood suppresses testosterone. Previous studies had shown childcare can lower testosterone levels.

**Procedure:** Six hundred and twenty-four Filipino men were followed in a **longitudinal study** for four and half years and had their testosterone levels measured at regular intervals.

**Findings:** Men with high waking testosterone were more likely to become partnered fathers by the time of the follow-up, four and a half years later.
Men who became partnered fathers then experienced significant declines in waking and evening testosterone, which were significantly greater than declines in single non-fathers.
Fathers reporting three hours or more of daily childcare had lower testosterone at follow-up compared with fathers not involved in childcare.

**Conclusion:** The findings suggest testosterone is involved with mating success because the men with high waking testosterone were more likely to become partnered fathers. The findings also suggest testosterone then declines rapidly after the men become fathers as a result of childcare because men involved in daily childcare had lower testosterone compared with fathers not involved in care.
It appears testosterone levels involve a trade-off between mating and parenting in human males, which is also seen in other species in which fathers care for young. It may be that testosterone helps men become socially dominant, which increases their chances of mating by competing with other males and then declines once children are born as more nurturing behaviours are needed.

EE To what extent can a specific hormone be used to explain a specific behaviour?

In paper 1 (SL and HL), speculate to what extent a cause-effect relationship can be inferred regarding pheromones and their effects. You also need to question whether or not pheromones can be said to exist as a researchable phenomenon in humans.

## 2.2 Pheromones and behaviour

### Content focus

Comment on the validity of evidence that pheromones may cause behaviour.

**Pheromones** are chemicals that are **secreted** outside of the body and may play a role in human behaviour by acting on other individuals who sense them and then respond in certain ways. Species use different pheromones for different roles, including marking territory or signalling a threat to other members of the same group.

Research regarding human pheromonal interactions is still in its infancy so firm conclusions cannot be drawn. However, discussions about the effect of pheromones on behaviour can be seen as a useful exercise in critical thinking.

## 2.2.1 Establishing validity

The validity of a study refers to its 'correctness' or 'accuracy' and can usually be established by asking: To what extent are researchers confident an identifiable cause has had an identifiable effect? Therefore, to satisfy notions of validity, researchers need to be able to show the actions of an identified pheromone and how it causes an odour-mediated behavioural or **physiological** response.

Given the biological assumptions of the subject matter, validity would have to be established through cause-effect experimental methods that are open to **peer review**. There would also have to be a clear identification of the active molecule involved in both the secretion and the response.

The following considerations can be discussed when attempting to establish the validity of a cause-effect relationship between pheromones and human behaviour: definitions, **theoretical evidence** and **empirical evidence**.

### Definitions

While there has been peer-reviewed research on other species regarding definitions and pheromonal effects, there has yet to be an established, coherent, peer-accepted definition of what a human pheromone constitutes, let alone what the effects on other individuals may be.

Researchers have agreed on certain aspects of pheromones. For example, for a pheromone to be considered a researchable phenomenon it has to be established as a coherent and singular entity that can be isolated and agreed upon in peer-reviewed research. It also has to be characteristic of an entire group rather than an individual. For example, all males of a species, rather than one individual, would have to secrete the chemical compound for it to be considered a pheromone. Moreover, it needs to be present in naturally-occurring sufficient quantities to cause an effect.

Researchers also know that, while some males may have more of a particular chemical compound and females may prefer those males, all individuals in the group have to be capable of producing that particular chemical compound for it to be considered a pheromone (Wyatt, 2014). According to Wyatt, pheromones have been identified in every part of the animal kingdom, including mammals, and are involved in a wide range of functions, including attraction**,** trail following, and interactions between parents and offspring. Although the effect of pheromones is dependent on the species, there is clear evidence that pheremones are a physiological mechanism that causes an effect in other non-human animals.

However, even with this understanding of pheromones, it has been difficult to establish whether or not they can be seen as a coherent and singular entity that can result in an agreed-upon definition. Most pheromones are not single compounds, but tend to be multi-component combinations of various other molecules (Logan, 2015).

TOK

To what extent should peer-reviewed reliability be a consideration when establishing validity? If researchers continuously demonstrate the same result are they more correct than researchers who cannot achieve reliability?

A key problem has been establishing whether or not pheromones can be seen as a coherent and singular entity that can result in an agreed-upon definition. Most pheromones are not single compounds, but tend to be multi-component combinations of various other molecules (Logan, 2015).

Moreover, the behaviour and actions of pheromone molecules create further problems for definition. For example, they can be volatile or involatile, soluble or insoluble, large or small, depending on whether they are carried to the receiver in air or water or deposited on the nasal sensors of the receiver (Wyatt, 2014). Humans produce many different chemicals for excretion, but research is still in its infancy regarding which of these could be considered pheromones and/or have an effect on another individual.

## Theoretical evidence

Humans are mammals and have been subject to the processes of evolution. Evolution involves **natural selection** as well as **sexual selection** (see p. 35). Darwin (1871) noted that adult males of mammal species such as goats and elephants have characteristic strong odours during their breeding season. He reasoned the evolution of specialized odour glands in male mammals is 'intelligible through sexual selection, if the most odiferous males are the most successful in winning the females, and in leaving offspring to inherit their gradually perfected glands and odours' (1871, vol. 2, p. 281, cited in Wyatt, 2015).

While different pheromones can be found across different species, it does not follow that because one species uses a molecule for the pheromonal effects, other unrelated species are necessarily likely to use the same molecules for the pheromonal effects.

In common with other mammals, humans show changes in gland development as they move toward sexual maturity via the processes associated with puberty. Other mammals have been found to have chemicals they use as pheromones in common with humans. For example, molecules with pheromonal effects in pigs were also detectable in human armpits. This was enough to lead some researchers (e.g. Kirk-Smith and Booth, 1980) to consider the same chemicals as being used by humans as pheromones. Therefore, it is reasonable to theorize that humans have developed communication strategies through the use of pheromones. However, while different pheromones can be found across different species, it does not follow that because one species uses a molecule for the pheromonal effects, other unrelated species are necessarily likely to use the same molecules for the pheromonal effects.

## Empirical evidence

For it to be asserted that pheromones play a role in human psychology it would need to be shown that humans have advanced **olfactory** abilities. Bushdid et al. (2014) sought to measure how effective humans were in distinguishing different odours. They designed a double-blind experiment where subjects were presented with three vials, two of which contained the same mixture, and the third contained a different mixture. The subjects were instructed to identify the odd odour vial based on odour quality.

Twenty different stimuli pairs were tested for a total of 260 mixture discrimination tests. Through computer programs the researchers calculated that humans can discriminate at least 1 trillion olfactory stimuli, suggesting humans have evolved to be highly effective smellers.

Given the physical abilities of humans to distinguish odours, it seems reasonable to assume that pheromones play a role in behavioural outcomes. Moreover, given the use of pheromones in other species in pair-bonding behaviour, it might be reasonable to assume they also play a role in human mating systems.

However, non-human mammals and non-mammal animal species like reptiles have a specific tissue in the nasal cavity, known as the **vomeronasal organ** (VNO), that detects most pheromones. While human fetuses are known to have a VNO, most current evidence holds that it is functionally inactive after birth (Verhaeghe et al. 2013).

Attraction is an important motivation in human pair-bonding behaviour and a key part of the sexual selection process outlined by Darwin. A biological approach to attraction assumes that it occurs between two people because the combination of their genes will result in healthy offspring.

Evidence for this assumption can be found in the attraction to individual odours in sweat, which carry information about a person's **immune system**. It is assumed genetically different immune systems complement each other and the mixture of the two immune systems should produce a child with a good immune system.

MHC genes, for example, control the immunological self/non-self discrimination and subsequently, tissue rejection and immune recognition of infectious diseases. Therefore, MHC genes help to ensure that people stay healthy. It is assumed MHC genes are the product of sexual selection to improve the immune system of offspring and avoid inbreeding. Studies in house mice indicate that both males and females prefer MHC-dissimilar mates, which they apparently recognize by odour cues. Studies in humans have also found MHC-associated odour and mating preferences (Wedekind and Penn, 2000).

## Key study: Wedekind et al. (1995)

**Aim:** To test whether a female will rate a sweaty t-shirt as more attractive if it is from a man with different immune system genes to her own.

**Procedure:** Forty-nine female and 44 male students were tested to see what type of immune system genes they had. The males were asked to wear a plain white t-shirt for two days. The t-shirts were put into closed boxes until the females were asked to smell them. The females were asked to rate the shirts for pleasantness and sexiness. The women rated the t-shirts as more pleasant and sexy if they came from a man with a different set of MHC genes.

**Conclusion:** Wedekind et al. concluded that people are motivated to find a mate with different immune system genes so their offspring will have stronger immune systems. This information is encoded in the body odour of the potential mate. It can be concluded as a result of this small-scale study that body odour, but not necessarily pheromones, is an important element of human **sociosexual** behaviour.

Studies in house mice indicate that both males and females prefer MHC-dissimilar mates. However, in humans, it seems body odour but not necessarily pheromones is an important element of human sociosexual behaviour.

Research with humans does not show that pheromones cause the effect of attraction simply because some individuals prefer the smell of certain other individuals.

At the current level of understanding, for a pheromone to be considered a researchable phenomenon it has to be established as a coherent and singular entity that can be isolated and agreed upon in peer-reviewed research. Moreover, it has to be characteristic of an entire group rather than an individual.

Wedekind et al.'s research focuses on individual body odour and, while it is likely molecules characteristic of all males of the species may well appear among the other molecules in an individual male's chemical profile (and can therefore be individually identified as pheromones), the research does not show that pheromones cause the

effect of attraction in humans simply because some individuals prefer the smell of certain other individuals.

Pheromones may be present in all bodily secretions, but most attention has been focused on 'sweat', which is thought to contain the steroid **androstadienone** (AND). It is present at much higher concentrations in male sweat and can be detected by women, albeit with wide variation in sensitivity (Verhaeghe et al. 2013).

How can researchers in the human sciences measure human experience and claim validity?

TOK

AND has been described as having pheromone-like activities in humans. For example, Wyart et al. (2007) measured salivary levels of the hormone cortisol in 21 **heterosexual** women after a brief exposure (20 sniffs) to AND and compared it to a control substance with similar olfactory qualities. They found smelling AND maintained a better mood, increased sexual arousal, and increased physiological arousal via significantly higher levels of cortisol.

These results are supported by Jacob et al. (2002), who compared the effects of AND with two controls by measuring the psychological states of a mixed-gender group of 37 participants who all identified as heterosexual. They used a double-blind repeated-measures experiment and found female participants showed increased positive-stimulated mood and reduced negative mood after exposure to AND when compared to male participants.

Verhaeghe et al. (2013) reviewed a number of studies regarding the effects of AND on women and found further empirical evidence for a mood uplift for women who were exposed to AND, although this was dependent both on its dose (Bensafi et al. 2004b) and on the pre-exposure mood prompted by a 'sad' or 'happy' video (Bensafi et al. 2004a). Other studies have shown AND can increase cooperation between heterosexual men (e.g. Huoviala and Rantala, 2013).

The studies presented here can be used to present a cautious conclusion that AND does have an effect on mood if presented in sufficiently large concentrations. However, the questions remain: Can AND can be defined as a pheromone at all? Can the naturally occurring concentrations produce an effect?

- Wyart et al. (2007) state in their research that 'whether [androstadienone] AND satisfies the key criterion for pheromonal action, influencing endocrine balance, remains unknown' (p. 1261). Therefore, they do not claim AND is a pheromone.
- Jacob et al. (2002) state that AND is a pheromone by claiming (without citation) how 'other researchers' have found AND has had unique effects on the surface of the vomeronasal tissue. They state: 'This apparent stimulus specificity was used to justify calling AND a pheromone' (p. 275) with no further justification. This claim is made despite other researchers suggesting the functionality of the vomeronasal tissue is inactive after birth in humans (Verhaeghe et al. 2013).

Empirical evidence is a very significant phrase in psychology. Make a wall chart that explains to passers-by the meaning of empirical evidence. Use examples of theories for which there is empirical evidence and examples for which there is no empirical evidence.

Ecological validity is lacking in the designs of many studies measuring the effects of pheromones. The methodology of various studies actually undermines the validity of any claim that suggests a 'pheromone' causes certain responses.

For example, chemicals are placed near or inside the nasal membranes in large amounts. This may be because the naturally occurring physiological levels appear to be too low to induce a response under experimental conditions and so researchers have to augment the amount and present it in unnatural ways.

Researchers need to show the actions of an identified pheromone and how it causes an odour-mediated behavioural and/or physiological response in a reliable, naturally occurring way in a peer-reviewed journal for scientific notions of validity to be satisfied.

Another key problem with studies relating to pheromones is finding a homogenous group of participants. For example, if asked to identify their sex and sexuality in order to account for it in the study, participants are prompted to the true purpose of the study, affecting its validity.

Furthermore, when participants are asked to smell a pheromone and then asked to report their mood, they can immediately guess the nature of the study and may also cognitively associate the smell with a boyfriend or husband rather than have a genuine physiological response to the chemical compound.

TOK

To what extent does the practice of reducing complex behaviours to singular or less complex entities help or hinder knowledge creation in Psychology?

In summary, empirical evidence is open to question about the supposed effects of pheromones. Researchers make mistakes in their approach, for example:

- They use small sample sizes.
- They use unnaturally large amounts of the chemical and forcibly present it in an unnatural way, questioning the ecological validity of their findings.
- They assume that if humans share chemical molecules with other mammals who use them for their pheromonal effects, humans must do too.
- Participants are often able to guess the nature of the study and associate certain smells with memories. Therefore, true validity via an odour-mediated behavioural or physiological response is difficult to establish.
- The effects of individual body odour are combined with pheromonal effects, which does not satisfy the definition of a pheromone.

# 3 Genetics and behaviour

**Topic focus**

To what extent can genetics be used to explain behaviour?

## 3.1 Genes and behaviour

**Content focus**

Discuss the links between genes and behaviour in the light of environmental factors.

Assume substantial links can be made between genes and behaviour. Use the deeply personal nature of human experience as well as the influence of the environment to add moderation to your argument. Do not assume definitive conclusions can be drawn about the relationship between genes and behaviour.

**Genes** are made up of **DNA**, which provides the blueprint for the structure and function of the human body and may include thoughts, feelings, and behaviour. Animals, including humans, are born with **innate** behaviours to allow them to react instinctively to some environmental stimuli in a way that enhances their prospects for survival (O'Brien, 2000). Therefore, genes are increasingly considered as candidates to explain complex behavioural traits (Stockinger et al. 2005).

Genotype refers to the genetic constitution of an individual organism.

Phenotype refers to the set of observable characteristics of an individual that is a result of the interaction between the genotype and its own environment.

However, not all genes that an individual might possess are expressed at all times, as genes can be switched on and off via various mechanisms. This gene regulation will result in differential gene expression, which means having a gene for a particular behaviour does not necessarily mean that an individual will exhibit that behaviour.

In sum, there is a difference between the **genome**, which refers to all the genes that an individual possesses, and the behavioural phenotypes, which refers to the patterns or sets of behaviours that are expressed and are dependent on genotype (DeCamp and Sugarman, 2004).

What ethical principles are relevant to the design of one's own offspring through technology?

TOK

## 3.1.1 Major depressive disorder

According to the *Diagnostic and Statistical Manual of Mental Disorders*, Fifth Edition (DSM-5), a person is suffering from major depressive disorder (MDD) if five or more of the following symptoms have been present during a two-week period and represent a change from previous functioning; and at least one of the symptoms is either (1) depressed mood or (2) loss of interest or pleasure.

- Depressed mood most of the day, nearly every day, as indicated by either subjective report (e.g. feels sad, empty, hopeless) or observation made by others (e.g. appears tearful). (Note: in children and adolescents, can be irritable mood.)
- Markedly diminished interest or pleasure in all, or almost all, activities most of the day, nearly every day (as indicated by either subjective account or observation.)
- Significant weight loss when not dieting or weight gain (e.g. a change of more than 5 per cent of body weight in a month), or decrease or increase in appetite nearly every day. (Note: in children, consider failure to make expected weight gain.)
- **Insomnia** or hypersomnia nearly every day.
- **Psychomotor** agitation or retardation nearly every day (observable by others, not merely subjective feelings of restlessness or being slowed down).
- Fatigue or loss of energy nearly every day.
- Feelings of worthlessness or excessive or inappropriate guilt (which may be delusional) nearly every day (not merely self-reproach or guilt about being sick).
- Diminished ability to think or concentrate, or indecisiveness, nearly every day (either by subjective account or as observed by others).
- Recurrent thoughts of death (not just fear of dying), recurrent suicidal ideation without a specific plan, or a suicide attempt or a specific plan for committing suicide.



There is a significant body of evidence that demonstrates MDD has its causes rooted in biology, which suggests a clear link between the disorder and genes. However, it can also be noted that no single genetic variation has been identified to increase the risk of depression. It seems likely that multiple genetic factors, in conjunction with environmental factors, lead to the development of MDD (Lohoff, 2010).

The study of twins – namely comparisons between identical twins and fraternal twins – can be used to disentangle the relative **etiological** influence of genes versus environmental causes. Identical (MZ) twins share all of their genes, whereas fraternal (DZ) twins only share about half. Therefore, any significant differences between MZ twins can be attributed to the environment. The study of twins is also useful in showing the importance of a unique environment, one that is specific to one twin. Unique environments can occur in multiple ways, for example when the twins have been separated or one has suffered a head injury or maintained a different diet.

A traditional twin design compares the similarity of MZ twins with DZ twins. If MZ twins have significantly more similarities than DZ twins this suggests that genes play an important role in these traits.

For example, Kendler et al. (2006) compared the incidence of the symptoms of depression among MZ and DZ twins. The researchers used telephone interviews to ask 42,000 twins if they and their family members had symptoms of depression. The findings showed a significantly higher rate of correlation among MZ twins than DZ twins, suggesting a clear genetic component.

The basic principle of **genetic association** studies is that a genetic variant is investigated in a group of cases and controls. By determining the allele or genotype frequencies and comparing them statistically, the probability that a gene is more frequent in one group than the other can be investigated (Lohoff, 2010). For example, the serotonin-transporter (5-HTT) gene has come under particular scrutiny because it is connected to the reuptake of serotonin in the synapses. It is assumed adaptations in this gene may influence the incidence of MDD in an individual.

Twin studies can be used to disentangle the relative etiological influence of genes versus environmental causes. They do this by comparing the similarity of identical twins and fraternal twins.

TOK

Can universal assumptions be applied to all humans? Does the methodology of psychology downplay individual differences as well as culturally specific details?

## Key study: Caspi et al. (2003)

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

**Procedure:** A natural experiment was conducted where the naturally occurring IV was the length of the alleles on the 5-HTT gene. An opportunity sample was used, consisting of 847 participants all aged 26 who were taking part in another study. Their age was controlled to isolate the variable of 'number of stressful life events' between the ages of 21 and 26. The participants were split into three groups, depending on the length of the alleles on their 5-HTT transporter gene.

Group 1 – two short alleles
Group 2 – one short and one long allele
Group 3 – two long alleles

Stressful life events that occurred after the 21st birthday and before the 26th birthday were assessed using a life-history calendar so the participants could show when the events occurred as well as their intensity. They were standardized around the following themes: employment, financial, housing, health and relationships. Instances of depression were assessed using the Diagnostic Interview Schedule that occurred during the year preceding the study. A correlation assessed: between stressful life events and depression; between the length of the alleles and depression; and for any interaction between perception of stress and the length of the alleles.

**Findings:** Group 1 participants with two short alleles in the 5-HTT gene reported more depression symptoms in response to stressful life events than the other two groups.
Experiences of childhood maltreatment were predictive of depression in adulthood, but only in adults with either one or two short alleles.
Participants with two long alleles reported fewer depression symptoms.

**Conclusion:** The serotonin transporter (5-HTT) gene was found to moderate the influence of stressful life events on depression. The study provides evidence of a gene-by-environment interaction, in which an individual's response to environmental stimuli is moderated by his or her genetic make-up. In particular, the presence of short alleles on the 5-HTT gene may increase the risk of developing MDD.
However, since a large proportion of the population carries the mutation of the 5-HTT gene, which may make them susceptible to depression after traumatic events, it can be difficult to conclude that the gene is a major contributor to depression because most people do not have significant MDD symptoms.
The findings suggest the long alleles may protect against suffering depression as a result of stress.

**Criticism:** It should be noted that the effects of the gene adaptation are dependent on the type of environmental exposure to stress. People who did not carry the mutation can also become depressed. Another limitation of this study is the symptoms of depression were **self-reported**. One person's perception of being depressed will not be the same as another's. This problem is compounded by the perception of what constitutes a 'stressful life event'.

A key problem with gene–environment research is deciding what should be measured and how. MDD is a complex and deeply personal illness and can manifest in different ways for different individuals. Moreover, there are **gender** and sociocultural influences on how MDD manifests.

One approach is for researchers to use **clinically diagnosed** patients and then use quantifiable data. For example, Peyrot et al. (2013) compared MDD patients (defined by a lifetime DSM-IV based diagnosis) to healthy controls who had not been diagnosed, as well as suicidal MDD patients to healthy controls.

Data from 1727 unrelated MDD patients and 1792 healthy controls from the Netherlands Study of Depression and Anxiety (NESDA) and the Netherlands Twin Registry (NTR) were analysed. The MDD patients were compared to healthy controls with respect to age, gender, and the environmental factors of 'lifetime and recent stressful life-events', 'sexual abuse', 'low educational attainment', and 'childhood trauma'. They examined whether the gene that codes for the serotonin transporter (5-HTTLPR) could have a direct effect on the outcomes of MDD patients.

They used t-test and chi-square statistics and found no significant effect for 5-HTTLPR on outcomes for MDD patients. However, there was a possible small influence of the gene on how the illness will develop over time. They found environmental factors had large and consistent direct effects on both prevalence and course of MDD (how an

illness develops over time) and they state the environmental impact is stronger for the more severe outcomes, such as suicide.

Sullivan et al. (2000), conducted a **meta-analysis** of relevant data from primary studies of the genetic links to major depression. They concluded that MDD is a familial disorder that mostly or entirely results from genetic influences. However, environmental influences specific to an individual are also etiologically significant, but this is not the case for the broader environmental influences shared by other members of the family.

Therefore, MDD is a complex disorder that does not result from either genetic or environmental influences alone, but rather from both, but with a particular emphasis on individual interactions with their environment.

The studies suggest that MDD is a deeply personal disorder with a complex mode of **inheritance**. Therefore, it is likely that multiple genes with small effects are involved. Moreover, identifying genetic factors is complicated by the significant environmental components that affect each individual differently (Lohoff, 2010). Trying to identify singular causes is further complicated by different perceptions of what constitutes MDD symptoms as well as what a stressful environmental factor may well vary from one individual to the next.

### 3.1.2 Factors that affect gene expression

**Epigenetics** is the study of changes in organisms caused by **genetic expression** rather than changes in the underlying genetic code. The protective package of proteins around which genetic material is wrapped can be influenced by environmental factors, which in turn influence how the genes express themselves. Therefore, the **epigenome** plays a crucial role in determining which genes actually express themselves in a creature's traits: in effect, it switches certain genes on or off, or turns them up or down in intensity. Not only can these changes influence genetic expression, they can also be passed on to the individual's offspring.

Epigenetics is the study of changes in organisms caused by genetic expression rather than changes in the underlying genetic code.

Epigenetic modifications are thought to be one mechanism to explain how environmental stressors influence gene expression and can therefore help explain risk to abnormal behaviours (Klengel et al. 2014; Menke and Binder, 2014).

In particular, childhood adversities have been associated with onset of MDD via epigenetic changes (Kang et al. 2013). One way epigenetic influence may occur is via the process of methylation, which is used by cells to control gene expression. Methylation is the process where methyl groups are added to the DNA molecule, which can change the activity of a DNA segment without changing the underlying sequence.

Kang et al. (2013) measured the methylation status in the promoter of gene encoding serotonin transporter (SLC6A4) in 108 patients with MDD and correlated it with childhood adversity. They found that higher SLC6A4 promoter methylation status was significantly associated with childhood adversities, suggesting a link between environmental experiences and gene activity.

**Key study: Natt et al. (2009)**

**Aim:** To test whether unpredictable food access would act as an environmental stressor to chickens and cause them to adopt a more dominant feeding strategy.

**Procedure:** Chickens were placed in a controlled environment. The IV was either predictable or unpredictable feeding environment and was operationalized by manipulating light and darkness. The DV was the level of dominance in feeding and was operationalized by counting the amount of pecks for food. The chickens were allowed to breed and then all offspring were separated from their parents.

**Findings:** Chickens adapted their feeding behaviours in response to changes in their environment. The offspring of such chickens can retain these adaptive behaviours despite never being directly exposed to the same environment. Furthermore, levels of **estradiol** (a hormone chiefly secreted by the ovaries) were significantly higher in egg yolk from birds exposed to unpredictable feeding environments, suggesting one possible mechanism for these effects.

**Conclusion:** Chickens that became dominant passed their dominant behaviour on to their offspring despite not interacting with them. Hormonal changes in the chickens influenced their genetic expression and made their offspring better adapted to a problematic environment.

To what extent can specific genes be used to explain a specific behaviour?

EE

## 3.2 Genetic similarities

**Content focus**

Explain the concept that the greater the genetic similarities between two individuals or a group of individuals, the higher the degree of relatedness.

Show an awareness of the degree of relatedness between MZ and DZ twins, siblings, parents and children, and parents and adopted children. This will provide a critical perspective in evaluating twin or kinship studies.

Genetic similarity is referred to as relatedness and it is assumed the greater the genetic similarities between two individuals or a group of individuals the higher the degree of relatedness.

Genetic similarity is referred to as **relatedness** and it is assumed the greater the genetic similarities between two or more individuals, the higher the degree of relatedness.

Relatedness is measurable and is known as the coefficient of the relationship between two individuals. It is usually expressed on a scale of 0–1 with 1 representing the highest level of genetic similarity and 0 representing individuals who have arbitrarily remote common ancestors. It is a useful construct for societal and legal purposes to measure levels of inbreeding and to help courts decide who should be allowed to form relationships.

Twin studies are used to disentangle the relative etiological influence of genes versus environmental causes. They do this by comparing the similarity of identical twins (MZ) and fraternal twins (DZ). MZ twins share all of their genes whereas DZ twins only share about half. Therefore any significant differences between MZ twins can be attributed to the environment. Twins are also useful in showing the importance of a unique environment that is specific to one twin. Unique environments can occur when the twins have been separated or one has had a head injury or a different diet, etc. A traditional twin design compares the similarity of MZ twins with DZ twins. If MZ

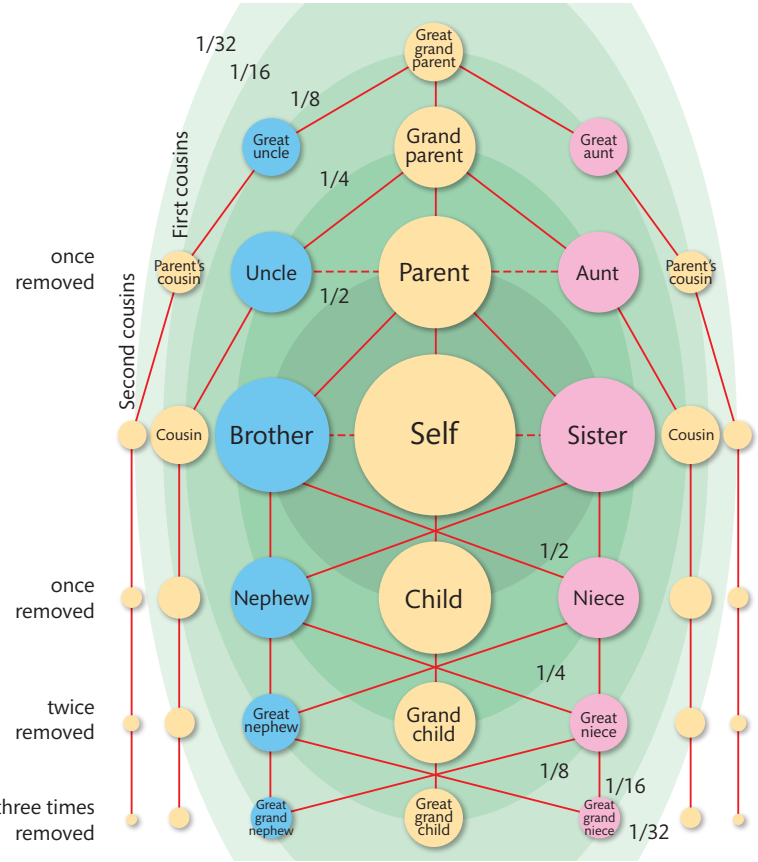


**Figure 3.1** Common family relationships, where the area of each coloured circle is scaled relative to the degree of relatedness. All relatives of the same relatedness are included together in the green ellipses.

twins have significantly more similarities than DZ twins, this suggests that genes play an important role in these traits.

The Minnesota Twin Family Study (MTFS) is a longitudinal study of twins conducted by various researchers associated with the University of Minnesota. The aim of the study is to identify and measure the level of genetic and environmental influences on the development of psychological traits such as IQ, academic ability, personality, interests, family and social relationships, mental and physical health. It involves several independent but related projects that use different measurements, researchers, and participants to meet the aim of the overall study.

For the intelligence area of the study, they measured statistical correlations between performance on IQ tests with degree of genetic relatedness. This was modified by the degree of **familiarity**, which refers to whether or not they were raised in the same family. There are three degrees of genetic relationships, R=0.0 for unrelated persons, R=0.5 for either Parent x Child or Sibling x Sibling (including DZ twins), and R=1.0 for MZ identical twins. The data shows that related persons have more similar IQ test scores than unrelated persons. The results also show that the similarity of scores increases with degree of relatedness.

The results show that identical twins raised together are more similar than those raised apart. This clearly shows an environmental influence on IQ test scores. However, a note of caution is needed when considering the influence of the environment on identical twins raised apart. Western countries, when placing children up for adoption,

TOK

Some cultures allow individuals with a high degree of genetic relatedness – such as first cousins – to form relationships and have children. This cultural norm can produce birth defects such as the blood disorder thalassemia, which leads to anemia. Can cultural norms be measured and ranked within a system of ethics?

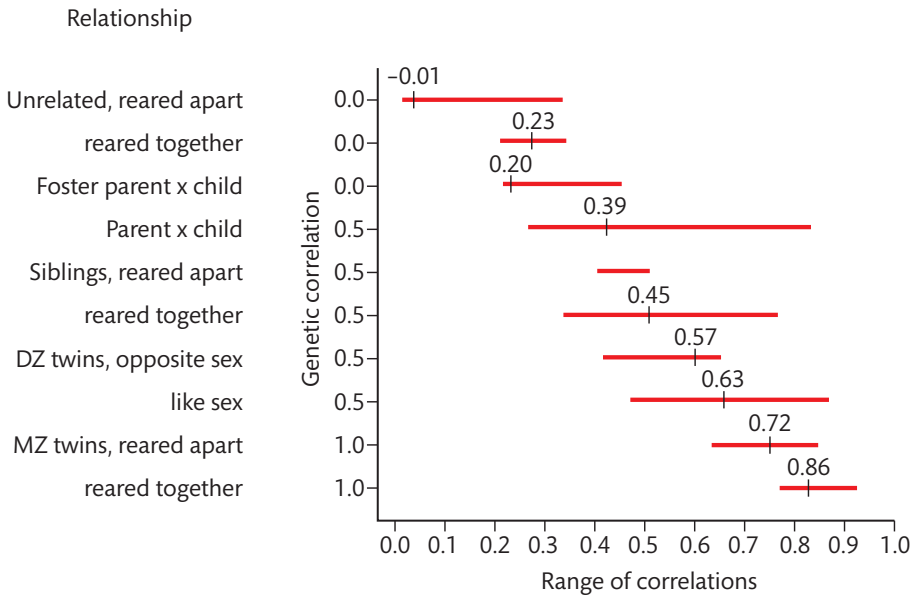


**Figure 3.2** The similarity of IQ scores when compared to the degree of genetic relatedness.

have strict guidelines regarding the type of environment they can be placed into. This usually means a loving, economically stable home where the adopting parents can clearly show they can provide for the best interests of the children. Therefore, even when identical twins are adopted into separate families, it can be assumed they are being raised in relatively similar socioeconomic and emotional environments.

When raised in the same family, siblings and identical twins are on average more similar than those raised apart. This result even applies to pairs of unrelated persons. Therefore, this indicates that familiarity (similarity of family background) has a significant influence on IQ test scores.

The results indicate that performance on IQ tests is highly heritable, but they also show a significant influence of environmental factors on IQ test scores.

Plomin and Deary (2015) propose three 'laws' of genetics for complex behavioural traits that can be used to summarize the debate over genetic versus environmental influence:

- all traits show significant genetic influence
- no traits are 100 per cent heritable
- heritability is caused by many genes of small effect.

They also argue that intelligence is one of the most heritable behavioural traits.

Clearly label a very specific behaviour and use research to show why it can be considered an adaptation. To show critical thinking, use sociocultural explanations to argue that while human behaviour can be explained by evolutionary pressures, humans are also subject to other influences, which means there are very few behaviours with an absolute delineable relationship between biology and behaviour.

## 3.3 Evolutionary explanations for behaviour

### Content focus

To what extent can evolutionary pressures be used to explain behaviour?

**Evolutionary psychology** is a theoretical approach that assumes human thoughts, feelings, and behaviours have been subjected to **evolutionary pressures**.

The approach seeks to identify which human psychological traits have evolved as adaptations.

The term adaptation refers to functional products of natural selection or sexual selection in human evolution. In the following section human attachment, human sexual behaviour, and Major Depressive Disorder (MDD) will be discussed.

Evolutionary psychology is a theoretical approach that assumes human thoughts, feelings and behaviours have been subjected to evolutionary pressures.

## The Theory of Natural Selection

The Theory of Natural Selection was initially developed by Charles Darwin in the 19th century.

The theory has two main assumptions:

- evolution is caused by natural selection
- evolution is caused by sexual selection.

### Basic assumptions of natural selection

- The resources needed for survival are limited.
- There is a struggle to survive in the environment.
- Environments present challenges to individuals and species.
- Individuals in the population have variations in their traits due to genetic mutations (although Darwin did not fully understand this). Such variations in traits make the individual organism more or less suited to its environment.
- Individuals with better adapted traits have more chance of surviving and passing their better adapted genes on to the next generation.
- Individuals with less well adapted traits have less chance of surviving and passing their less well adapted genes on to the next generation.
- Over time, genes that render the individual better adapted will exist in greater numbers and the trait that was successful will be seen more in the population.
- Genes that render the individual less well adapted will exist in fewer numbers and the trait that was less successful will be seen less in the population – possibly eventually dying out.

**A note on language**

The phrase 'survival of the fittest' is often applied to summarize Darwin's theory. In the 19th century when the term was coined it was interpreted as 'survival of the best fitted' but over time 'fittest' became less synonymous with 'fitted' and became more synonymous with 'healthy' or 'physically fit'. The underlying assumptions of Darwin's theory became misinterpreted by poor language choice on the part of subsequent authors and theorists who still continue to use the term 'fittest' when the meaning has changed in mainstream society. To be clear, the underlying notion of 'survival of the fittest' should interpreted as 'survival of the best adapted' whereby organisms with the most appropriate traits in the context of their environment are the most likely to survive, thrive and reproduce.

TOK

To what extent does language impact knowledge creation? To what extent should language be standardized across the social sciences? What can other languages offer in terms of bringing new meaning and understandings to knowledge?

## Basic assumptions of sexual selection

- There is a struggle to breed in the environment. (Note: Darwin referred to it as the 'sexual struggle'.)
- Sexual selection takes place between individuals of the same sex (generally the males) in order to drive away or kill their rivals; to attract those of the opposite sex (generally the females) who then select the more agreeable partners.
- Better adapted organisms have characteristics that render the individual more sexually attractive – and therefore more likely to mate.
- Individuals with better adapted sexual traits have more chance of breeding and passing their better adapted genes on to the next generation.
- Individuals with less well adapted sexual traits have less chance of breeding and passing their less well adapted genes on to the next generation.
- Over time, genes that render the individual better sexually adapted will exist in greater numbers and the trait that was successful will be seen more in the population.
- Genes that render the individual less sexually adapted will exist in fewer numbers and the trait that was less successful will be seen less in the population – possibly eventually dying out.

**A note on genes**

When Darwin presented his theory in the book *On the Origin of Species*, he was not aware of the biological processes through which traits are inherited (now known as genes). Therefore, it is not accurate to talk of genes or genetic adaptability in terms of Darwin's own writings, but it is accurate to talk of genes or genetic adaptability in terms of the Theory of Natural Selection.

TOK

To what extent do theories help and hinder knowledge creation in the human sciences?

## 3.3.1 Attachment

**Attachment** behaviours show the basic mechanisms of natural selection. Attachment is a deep and enduring emotional bond that connects one person to another across time and space (Ainsworth, 1973; Bowlby 1969). Bowlby defined attachment as a 'lasting psychological connectedness between human beings' (1969, p. 194).

Infants have a universal need to seek close proximity with their caregiver when under stress or threatened (Prior and Glaser, 2006) and therefore, attachment in children is characterized by specific behaviours, such as seeking proximity with the **attachment figure** when upset or threatened (Bowlby, 1969). Attachment behaviour in adults toward a child includes responding sensitively and appropriately to the child's needs. Such behaviour appears universal across cultures.

Attachment theory provides an explanation of how parent–child relationships emerge and then influence further development. Bowlby and Robertson (1952) observed that children experienced intense distress when separated from their mothers. Even when such children were fed by other caregivers, this did not diminish the child's anxiety.

The behavioural theory of attachment assumed children became attached to the mother because she simply fed the infant and attachment was a learned response through association. However, Bowlby (1958) proposed that attachment can be understood within an evolutionary context in that the caregiver provides safety and security for the infant and attachment should therefore be seen as an adaptive trait as it enhances the infant's chance of surviving and thriving.

Attachment and the evolutionary benefits are illustrated by the work of Lorenz (1935) on imprinting. Lorenz took a large clutch of goose eggs and kept them until they were about to hatch. Half of the eggs were then placed under a goose mother, while Lorenz kept the other half beside himself for several hours.

When the geese hatched, Lorenz imitated a mother duck's quacking sound so the young birds regarded him as their mother and followed him accordingly. The other group followed the mother goose.

Lorenz found that geese follow the first moving object they saw, during a 12- to 17-hour critical period after hatching. This process became known as **imprinting**, and suggests that attachment is innate and programmed genetically. To ensure imprinting had occurred Lorenz put all the goslings together under an upturned box and allowed them to mix. When the box was removed the two groups separated to go to their respective 'mothers' – half to the goose and half to Lorenz.

Hess (1958) showed that although the imprinting process could occur as early as one hour after hatching, the strongest responses occurred between 12 and 17 hours after hatching, and that after 32 hours the response was unlikely to occur at all. Imprinting occurs without any feeding taking place, undermining any stimulus-response explanation via external stimuli.

Using animals in this way allowed a variable to be isolated (proximity of an attachment figure) and then measured (mixing the geese with other non-attached youngsters), which would not be possible with humans.

Lorenz worked with geese to demonstrate how the mechanism of imprinting is important for attachment.

Bowlby (1958) proposed that attachment can be understood within an evolutionary context in that the caregiver provides safety and security for the infant and attachment should therefore be seen as an adaptive trait as it enhances the infant's chance of surviving and thriving.

Attachment and the evolutionary benefits are illustrated by the work of Lorenz (1935) on imprinting.

## 3.3.2 Major Depressive Disorder

There is a significant body of evidence that demonstrates MDD has its causes rooted in biology and, therefore, evolutionary psychologists ask if there could be evolutionary benefits to the disorder – can it be seen as a **Darwinian adaptation**?

Given the deeply personal, as well as cultural, elements to MDD, it can be challenging to disentangle the relative sociocultural versus biological elements of the disorder. Therefore, twin studies are often used.

Kendler et al. (2006) compared the incidence of the symptoms of depression among identical and non-identical twins. The researchers used telephone interviews to ask 42,000 twins if they and their family members had symptoms of depression. They found a significantly higher rate of correlation among MZ twins than DZ twins, suggesting a clear genetic component.

Genes manifest in complex ways. It is enough to assume they influence neurological frameworks as well as hormonal and neurotransmitter levels and sensitivity. The monoamine hypothesis assumes there is a lack of certain neurotransmitters that are responsible for varied outcomes, which then leads to depression. For example, a lack of serotonin may be related to anxiety, obsessions, and compulsions. A lack of dopamine may be related to reduced attention, motivation, pleasure, and reward, as well as interest in life (Nutt, 2008). Evidence of this comes from certain drugs that raise the levels of serotonin and dopamine and improve the mood of sufferers.

The presence of genetic determinants for MDD suggest there could be evolutionary benefits to the disorder. For example, the conservation of resource theories assume depression is a mechanism that leads to the inhibition of certain desires. This could be beneficial because they would enable the individual to give up unattainable goals, to conserve resources, and to redirect them to more productive tasks (Nesse, 2000).

Social competition theories assume depressed mood is an answer to a perceived descent in social hierarchy. Any descent in social hierarchy may lead to further attacks, as higher ranking individuals may seek to assert their dominance over perceived lower ranking individuals. Therefore, specific behaviours accompanying depression would correspond to the loss in social rank and project messages that might serve to protect an individual from possible attacks (Price, 1998).

In keeping with the notion of depression serving to regulate group dynamics, the **attachment theory of depression** assumes depressive responses serve as a distress call (Frijda, 1994) to other members of the group as a way of signaling for help and reassurance and improving group bonds.

Given the underlying assumption that depression fulfills a **social projection** role within group dynamics it could be assumed that rates between males and females would be approximate. However, this is not proven by the research. Kessler et al. (1994) reported that women in the US are about two-thirds more likely than men to be depressed, with a similar trend in the UK. However, seen through an evolutionary lens, women and men have different social functions within groups as well as distinct gender roles and identities.

It could be assumed that if depression is a social projection, it might affect men and women differently. Therefore, gender differences in depression rates may be the

result of the two genders responding to sociocultural pressures, which would mean their underlying depression symptoms manifest themselves in gender-specific ways (Nazroo, 2001).

For example, men may have been **socialized** to express depression symptoms in the form of anger, seeking solitude, or turning to drugs, or other forms of acting out; whereas women are more likely to talk about their feelings in social settings and peer groups, prompting them to be labelled as 'depressed' and seek help.

Women may also feel more comfortable seeking help with personal problems from healthcare professionals as a result of sociocultural expectations regarding women's behaviour. Studies have shown that expected gender differences in depressive disorders were balanced out by higher male rates of alcohol abuse and drug dependency (e.g. Metzler et al., 1995), suggesting there is no underlying biological difference between men and women in experiencing these feelings, but the social projections are dependent on sociocultural norms.

EE

To what extent can a specific behaviour be explained as an evolutionary adaptation?

# 4 Research methods: biological approach

**Learning focus**

Discuss the contribution of research methods used in the biological approach to understanding human behaviour.

Show an awareness of the specific research methods used in the biological approach. They should be clearly labelled, defined and supported with examples that illustrate their strengths and limitations. It is important to show a practical awareness of how psychology research is carried out.

Research within the biological approach aims to uncover how biological phenomena influence psychology. Therefore, it is very scientific in nature, which assumes a reductionist position on many behaviors with attempts made to make causal links between biology and psychology. These underlying scientific assumptions are reflected in the type of methods discussed below.

## 4.1 Experiments

Experiments are usually designed with one clear independent variable (IV) that is manipulated, and a dependent variable (DV) that is measured. All other factors that may affect the dependent variable are controlled as far as possible. The precise nature of experiments allows other researchers to attempt to replicate the methodology to test the findings for reliability.

Experiments are usually designed with one clear independent variable that is manipulated and a dependent variable that is measured. All other factors that may affect the dependent variable are controlled as far as possible.

Experiments are used to test the validity of claims by asking to what extent there is a causal relationship between two variables. However, because of their tightly controlled nature they lack ecological validity and caution should be used when generalizing the data to more realistic scenarios.

For example, Wagner et al. (1979) measured the effects of reduced levels of testosterone on aggression in male mice. The IV was the level of testosterone operationalized by the mice being first castrated and then injected with testosterone. The DV was levels of aggression operationalized by the number of bites.

They found that castration reduces aggression and then testosterone restores aggression in castrated mice who were previously judged to be aggressive. When the injections ceased, it led to reduced levels of aggression again. Therefore, they were able to show that testosterone does have a causal relationship with aggression in mice.

This study lacks ecological validity because the isolation of singular or a small number of variables in experiments investigating biological phenomena is reductionist in nature and has the benefit of isolating biological mechanisms and testing to what extent they cause effects. The drawback is they fail to take wider factors that influence behaviour, such as sociocultural influences, into account.

## 4.2 Natural experiments

In a natural experiment researchers find naturally occurring variables and study them. They have the benefit of studying behaviour as it naturally occurs, which increases the ecological validity.

In a natural experiment researchers find naturally occurring variables and study them. They have the benefit of studying behaviour as it naturally occurs, which increases the ecological validity. Moreover, it allows researchers to conduct research that would otherwise be unethical. For example, Gettler et al. (2011) conducted a longitudinal study where they measured testosterone levels in men over time.

As researchers they would not be allowed to deliberately or artificially manipulate these levels because they wanted to determine if fatherhood suppresses testosterone (previous studies had shown childcare can lower testosterone levels), or if men with lower testosterone were more likely to become fathers – thereby establishing clear cause and effect. Six hundred and twenty-four Filipino men were followed for four and half years. They found:

- Men with high waking testosterone were more likely to become partnered fathers by the time of the follow-up four and a half years later.
- Men who became partnered fathers then experienced significant declines in waking and evening testosterone, which were significantly greater than declines in single non-fathers.
- Fathers reporting three hours or more of daily childcare had lower testosterone at follow-up compared with fathers not involved in childcare.

While this may appear to establish causality, the use of natural experiments meant they did not have full control over confounding variables, which undermines any claims to causality.

By now you have read about behaviours or behaviour-related issues, such as memory, aggression, and depression. Make a list of any three behaviours or behaviour-related issues that you would like to investigate or know more about. Why do you want to know more? Make a poster that asks a psychology-related question and the reason why you think it is an important question.

## 4.3 Correlations research

**Correlations research** has a focus on two variables and researchers attempt to uncover the strength of the relationship between the two. Correlations research provides an initial platform allowing later studies to narrow the findings down and, if possible, determine causation via more focused means. Correlational research also allows researchers to collect much more data of a greater variety than simple experiments can.

For example, Kendler et al. (2006) compared the incidence of the symptoms of depression among identical (MZ) and non-identical (DZ) twins. The researchers

used telephone interviews to ask 42,000 twins if they and their family members had symptoms of depression. The findings showed a significantly higher rate of symptoms of depression among MZ twins than DZ twins, suggesting a correlation between a genetic component and incidences of depression. However, it did not allow the researchers to claim a cause-effect relationship as so many other variables were involved.

## 4.4 Quasi-experiments

**Quasi-experiments** allow participants to be grouped based on a characteristic of interest to the researcher. For example, Raine et al. (1997) was interested in the brain activity of murderers versus non-murderers. The characteristic of 'murderer' was defined by the researchers and then they set about locating individuals who met their definition and were prepared to take part in research.

Quasi-experiments allow participants to be grouped based on a characteristic of interest to the researcher.

They used a PET scan to investigate whether there was dysfunction in the same brain areas of all participants. With quasi-experiments there is a lack of random assignment into test groups because the groups are chosen on the grounds of their inherent characteristics. This makes conclusions about causality less definitive and makes it more difficult to compare test groups, which can limit the generalizability of the results to a larger population.

Therefore, many quasi-experiments use a matched-pairs design so that the variables can be isolated and compared as much as possible. Raine et al. matched each murderer with a 'normal' subject for age, sex and diagnosis of schizophrenia, where necessary. Other variables were excluded because each participant was screened to exclude physical and mental illness, drug taking and a history of murder. Therefore, the variable of 'murder' had been isolated.

In this way, the groups become comparable, although it should be remembered that quasi-experiments are almost always performed retrospectively (in this case after the murders had taken place), which means the researcher has less control over past or hidden variables. For example, Raine et al. could not exclude participants who lied about taking drugs or had a hidden mental illness, and the participants' past criminal background was a naturally occurring variable outside of the study's control.

# 5 Ethical considerations: biological approach

**Learning focus**

Discuss ethical considerations used in the investigation of the biological approach to understanding human behaviour.

Show an awareness of the specific ethical considerations related to the biological approach. They should be clearly labelled and supported with examples of good and bad practice. It is important to show a practical awareness of how psychology research is carried out.

Ethics refers to a moral framework that differentiates 'right' from 'wrong'. All social science research carries ethical responsibilities because researchers interact with their participants and have to respect the **autonomy** and dignity of persons they research. In the research context this means that there is a clear duty to participants' knowledge, insight, experience, and expertise.

Ethics refers to a moral framework that differentiates 'right' from 'wrong'. All social science research carries with it ethical responsibilities because researchers interact with their participants.

Ethical considerations are more relaxed when working with animals, which allows researchers to focus on the variables and their effects rather than worry about the emotional welfare of participants.

**Biopsychology** is engaged in trying to uncover biological causations of behaviour. The search for biological mechanisms will inevitably mean a thorough investigation into human bodies and the effects on their thoughts, feelings, and behaviour.

## 5.1 The use of non-invasive techniques

With non-invasive techniques, human participants can be used to investigate biological causes of behaviour. For example, Maguire et al. (2006) made good use of MRI scans in conjunction with cognitive tests to investigate to what extent the various parts of the hippocampus could be correlated with certain types of topographical or spatial memory.

Non-invasive techniques do not cause harm to subjects and still give valuable insights into links between biological factors and behaviour. However, they can lack the accuracy of **post-mortem** techniques, such as autopsy, which are more normally used on animals (or after the natural death of the humans with explicit **consent** from them or their families). For example, post-mortems on Henry Molaison (see 1.1.3 fMRI) revealed damage to his brain tissue that previous non-invasive scans had not revealed.

How is balance achieved between ethical considerations and the pursuit of knowledge?

TOK

## 5.2 Informed consent

The Ethics Code of the American Psychological Association (2017) describes **informed consent** as follows.

Researchers should inform participants about:

- the purpose of the research, expected duration, and procedures
- their right to decline to participate and to withdraw from the research once participation has begun
- the foreseeable consequences of declining or withdrawing
- reasonably foreseeable factors that may be expected to influence their willingness to participate such as potential risks, discomfort, or adverse effects
- any prospective research benefits
- limits of confidentiality
- incentives for participation
- who to contact for questions about the research and research participants' rights.

Researchers should also provide opportunities for the prospective participants to ask questions and receive answers.

The case study of Henry Molaison (see 1.1.3, page 6) offers a good example of research into rare disorders caused by biological problems. Molaison is reported to have given

consent in 1992 for his brain to be used for research after death. However, serious questions can be asked as to how he could give informed consent as he could not retain the information presented to him, so did not have the ability to understand the research process. Lead researcher Suzanne Corkin eventually received informed consent from a living relative of Molaison's (a third cousin), but this raises questions about the 'closeness' of relatives and whether it refers to biological relatedness or an emotional closeness.

These matters are usually settled by a legal court. However, in the case of Molaison, a journalist, Luke Dittrich, was able to find relatives who could be considered closer to the participant (first cousins) but who were apparently not contacted by the researchers. Dittrich also documented that Corkin told him that Molaison was the only person signing his informed consent forms from at least 1981 to 1992 (Dittrich, 2016).

## 5.3 Minor deceptions

There are instances where informed consent is not necessary for researchers. Psychology researchers may dispense with informed consent:

- where research would not reasonably be assumed to create distress or harm and involves, for example, the study of normal educational practices, curricula, or classroom management methods conducted in educational settings; only anonymous questionnaires, **naturalistic** observations, or archival research for which disclosure of responses would not place participants at risk of criminal or civil liability or damage their financial standing, employability, or reputation, and confidentiality is protected; where there is no risk to participants' employability, and confidentiality is protected
- where otherwise permitted by law or federal or institutional regulations
- where mild deception is a reasonable approach to research, such as when the prospective scientific, educational, applied value, or non-deceptive alternative procedures are not feasible (Ethics Code of the American Psychological Association, 2017).

However, psychology researchers are not allowed to deceive prospective participants about research that is reasonably expected to cause physical pain or severe emotional distress. Researchers must also explain any deception that is an integral feature of the design and conduct of a study to participants as early as is feasible, which is usually at the conclusion of their participation, and allow participants to withdraw their data from the research if they wish.

## 5.4 Genetic research

Research with genetics requires a special set of ethical considerations because of the amount of data stored in genes. For example, predispositions for illness or certain behaviours, such as addictions, could be uncovered. A discussion always needs to happen within the research team and with the participants about what to do with this information and if and how it should be communicated back to the participants.

Research surrounding genetics:

- can reveal unexpected information that may harm or cause undue stress to research participants. For example, evidence of true parentage or unrevealed adoptions within a family or when a person discovers that he or she carries the gene for a particular genetic disorder.
- can often be complex and misunderstood. Participants and their families should be kept informed about the nature of genetic research.

Participants should know how their confidentiality will be protected, and what will happen to any genetic information obtained as part of the study. The aims and procedure of the study must be explained in plain language and participants must sign an informed consent form to show they have a clear understanding of the study they are participating in and its implications, including any potential harm.

TOK

To what extent can ethical frameworks be placed on a hierarchy? On what basis should ethical decisions be established and on what basis should ethical dilemmas be resolved?

Some groups may object to genetic studies as a cultural principle and, given the existence of other forms of discrimination against groups and the history of the **eugenics** movement, it is important to consult with relevant community leaders and organizations before genetic research is carried out. In such circumstances, consent must be seen as a community matter, not just an individual concern.

One way for researchers to protect the privacy of their participants is to use **coding**. Codes are assigned to the research material and only a small number of researchers have access to the codes. In this way researchers cannot link samples or information to particular people. This protects the confidentiality of individuals from insurance companies, employers, police, and others, but it also can limit the scientific value of the study by preventing follow-up and further investigation.

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Present a balanced argument about the use of animal research. Do not dismiss the role of animal models in psychology research as they are used widely and have a clear role to play in helping to uncover biological mechanisms that may cause human behaviour. However, your argument needs to show that researchers must be cautious when generalizing the findings of animal studies to human behaviour.

# 6 The role of animal research in understanding human behaviour (HL)

**General focus**

Discuss the role of animal research in understanding human behaviour.

## 6.1 The value of animal models

**Learning focus**

Discuss the value of animal models in psychology research.

Animal models are used in psychology research with the assumption that discoveries made will provide insight into the workings of human beings.

The value of animal models in understanding human behaviour can be seen in the following areas.

## 6.1.1 The manipulation and isolation of variables

Variables in areas of behaviour can be manipulated and isolated to a higher degree with animals than would be possible with human participants. Reductionist arguments can then be discussed in the context of causation.

For example, Wagner et al. (1979) measured the effects of reduced testosterone levels on aggression in male mice. The IV was the level of testosterone, operationalized by the mice being first castrated and then injected with testosterone. The DV was level of aggression, evident by the number of bites exhibited. They found castration reduces aggression and then testosterone restores aggression in castrated mice who were previously judged to be aggressive. When the injections ceased, it led to reduced levels of aggression again.

Methodologically this is a very tightly controlled study with a clear IV (testosterone) and a clear, quantifiable DV (number of bites exhibited), which would not have been possible if they had used human participants.

## 6.1.2 The benefit of a relatively quick breeding cycle

The breeding cycle of animals used in research is quicker than that of humans, which allows researchers to study the effects of **heredity** and environmental factors on behaviour.

For example, Natt et al. (2009) wanted to test the extent to which an unpredictable feeding environment would cause chickens to show a more dominant feeding strategy and whether that could be passed on to future generations purely by genetic means. They manipulated the feeding environment of chickens by manipulating the levels of light and darkness.

The DV was the level of dominance in feeding, found by counting the amount of pecks for food while separating the offspring from their parents. They found chickens adapted their feeding behaviours in response to changes in their environment, and the offspring of such chickens retained these adaptive behaviours despite never being directly exposed to the same environment.

They also found estradiol levels (a hormone chiefly secreted by the ovaries) were significantly higher in egg yolk from birds exposed to unpredictable feeding environments, suggesting one possible mechanism for these effects. Therefore, they were able to show how chickens who became dominant passed their dominant behaviour on, despite not interacting with their offspring. The hormonal changes in the chickens had influenced their genetic expression and made their offspring better adapted to a problematic environment.

## 6.1.3 The benefit of animal post-mortem study

The nature of animal research means brains can be accessed, manipulated and then measured post-mortem within a time frame convenient to researchers. The only way human brains can be accessed for post-mortem study is after the participant's natural death, having received permission.

For example, Gilles et al. (1996) aimed to create an animal model to show the effects of continuous chronic stress on corticosterone secretion in response to an acute

Without giving your opinion, ask five of your friends or family members if they think using animals in research is ethical. Ask them to explain why they think the way they do. Write a summary of all five of the discussions, synthesizing (combining) all of the arguments for and against, and then write a conclusion.

Animals are useful for researchers because variables can be manipulated and isolated to a high degree; the breeding cycle of animals allows researchers to study the effects of heredity and environmental factors on behaviour.

environmental stressor. Previous studies had used an absence of the mother to induce stress but the researchers wanted a model that could be comparable with human experiences. Stress was induced by placing newborn rats into an environment with their mothers that featured good or limited bedding before the rats were euthanized for the post-mortem. The group with limited bedding manifested increased corticosterone.

Gilles et al. were able to suggest the **paradigm** may more closely approximate the human situation of chronically stressed, neglected infants. The research is important because corticosterone secretion has a profound effect on the structure, development and function of the hippocampus, particularly via dendritic retraction – a form of neuroplasticity.

## 6.1.4 Caution in using animals to understand human behaviour

### Assumptions of similarity

The fact that humans are mammals and have been subjected to the processes of evolution can lead researchers to assume that traits with adaptive functions in other species have similar adaptive functions when found in humans. This can be problematic, as illustrated by the example of pheromones.

Darwin (1871) noted that male adult mammals of some species, such as goats and elephants, have strong odours during their breeding season. According to Wyatt (2014), these pheromones have been identified in every part of the animal kingdom, including mammals, and are involved in a wide range of functions including attraction, trail following, and interactions between parents and offspring.

Although the effect of pheromones is dependent on the species, there is clear evidence that pheromones are a physiological mechanism that cause an effect in other non-human animals. However, it has been difficult to establish whether or not pheromones can be seen as a coherent and singular entity that can result in an agreed-upon definition for humans.

Humans produce many different chemicals for excretion but research is still in its infancy regarding which of these could be considered pheromones and/or have an effect on another individual.

So, while there has been peer-reviewed research in other species regarding definitions and pheromonal effects, and these animal models have stimulated debate about the role of pheromones in humans, there has yet to be an established, coherent, peer-accepted definition of what a human pheromone constitutes, let alone what its effects on other individuals may be.

Moreover, while mammals share similar biological traits and structures with humans, they do not always respond to stimuli in the same way. For example, there are significant differences in the way that mice respond to diet and exercise when compared to human participants.

## Assumptions of objectivity

Researchers may assume that an animal is merely a research platform to test a hypothesis in living tissue. However, animals are also thinking and feeling organisms that respond in subtle and complex ways to their environment.

For example, Sorge (2014) measured the response of mice and rats to an injection in the ankle administered by a man or a woman. They measured the animal response using two methods: A **mouse grimace scale** (MGS) that examines facial expressions of pain in non-human animals, and the level of the stress hormone corticosterone in the animals' blood. In the results, the animals seemed to show a decrease in pain response of about 40 per cent when a man rather than a woman performed the injection.

They concluded that male researchers caused stress to the animals, which produced greater quantities of the stress hormone corticosterone in the blood and dampened the pain that the animals could potentially feel. The presence of a t-shirt placed with the animals also confirmed the findings, as the animals showed elevated levels of stress if it had been worn by a man rather than a woman.

These results show how the gender of the person handling the animals can have a significant effect on the biology of the animal in the study. Such findings should at least prompt researchers to report the gender of experimenters in their publications and to include their gender as a variable in any subsequent analysis.

Researchers have to be cautious in assuming humans and non-human animals are similar, and must be aware of how their own interaction with the animals will impact their results.

EE

To what extent can animal research help in understanding a specific human behaviour?

# 6.2 Measuring the value of animal research

**Learning focus**

Discuss whether animal research can provide insight into human behaviour.

One way to measure whether animal research can provide insight into human behaviour is to ask to what extent the knowledge is genuinely new.

For example, the extent to which the insight gained from Lorenz's geese experiments can be generalized to human emotional interactions is extremely limited. The need for vulnerable mammals to cling to older protective members of the group was a well established, observable trait before Lorenz sought to measure and replicate it. Therefore, questions remain about what level of 'new knowledge' was created in his studies.

It could be argued that using animals in this way allowed a variable to be isolated (proximity of an attachment figure) and then measured (mixing the geese with other non-attached youngsters), which would not be possible with humans. However, if the knowledge was already known before the experiments were conducted, questions can be asked about the purpose of the scientific study and the use of animals in the pursuit of insight regarding human behaviour.

Clearly define the notion of insight. Animal research has clear uses in psychology but there are also limitations to using it. Present a balanced argument with a clear thesis statement using examples from research to support them. Use the information from other higher level sections to build an argument.

TOK

To what extent will humans learn more about human life and personality from novels than from scientific psychology?

What is the purpose of the scientific approach in psychology?

A common theme in bio-psychology is the influence of reductionism and to what extent it helps generate insight into human behaviour. If the use of animals can help identify specific biological mechanisms that are connected to specific behaviours then this might qualify as insight. For example:

- Martinez and Kesner (1991) concluded that ACh played an important role in creating a memory of a maze in rats
- Rosenzweig and Bennett (1972) demonstrated the effect of a physically enriched environment on the thickness of the frontal lobe in rats.

In both examples, the manipulation of an environmental IV to measure the impact on a physiological DV would be ethically unacceptable on humans. Establishing a clear causal mechanism between the environment and a physiological response would only be possible with animal subjects. However, the main limitation of the research is that it is questionable to what extent these findings can be generalized to humans.

Another way to measure the extent to which animal research can provide insight into human behaviour is the level of predictability it can provide. Shanks et al. (2009) argue that the validity of any model can be assessed by its ability to predict what will happen. This is rooted in the testing of scientific hypotheses, which compare what is expected to occur with what actually occurs.

Animal models must be assessed on their ability to predict human responses. At the end of the series of animal experiments the researcher has a hypothesis that predicts a likely human response to the same stimulus.

Thus, those claiming animal models are predictive of human responses must show that what they claim is true. Shanks et al. (2009) argue there is an overarching hypothesis in the animal model community that assumes results from experiments on animals can be directly applied to humans and that animal models should be considered predictive. This assumption has led to an unquestioned methodological approach that means animals are used as surrogate humans.

However, animals and humans have markedly different biological reactions to the same stimuli despite having similar biological systems. For example, the Japanese Pharmaceutical Manufacturers Association found that 43 per cent of **clinical** toxicities for humans were not forecast from animal studies (Igarashi, 1994). Sankar (2005) argues that the majority of the drugs shown to be safe in animals end up failing in clinical trials and animal models have only a 10 per cent predictive power, since 90 per cent of drugs fail in the human trials.

TOK

To what extent should animal models be reliably predictive? How should levels of prediction be measured? To what extent should psychology be held to the same standards as the natural sciences, or should some leniency be used when discussing prediction in complex social systems?

In summary, caution should be used when assuming biological causation. This is especially true when the complex social systems of various species are taken into account. For example, Wagner et al. (1979) were able to connect testosterone to aggression in male mice. However, Dreher et al. (2016) suggest that testosterone could have played a key evolutionary role for humans by not only promoting aggressive behaviour but also increasing feelings of generosity, leading to more generous behaviour, which leads to a higher social status.

Human studies undermine the impression of a simple causal link between testosterone and male aggression that animal models can create. Instead, it seems likely that testosterone's effect on human male behaviour depends on the social context in

which it occurs. In other words, while testosterone is linked to aggression, it is simply a hormone that leads to higher ranking of human males. Aggression is one route to achieve that, but not the only route. Rats have no option but to be aggressive because they are less complex creatures.

## 6.3 Ethical considerations

### Learning focus

Discuss ethical considerations in animal research.

The treatment of animals is rooted in cultural norms. Western psychology researchers work within a culture influenced by Judeo-Christian teachings, which have an assumption that humans hold dominion over animals, allowing them to use them for their needs. However, Judeo-Christian teachings also encourage the kind treatment of animals while suggesting that deliberate cruelty represents a flawed moral character on the part of the human.

The underlying moral assumptions that have evolved for the ethical treatment of animals are as follows.

- It is acceptable to use animals for human ends. However, the purpose of the use must be of some benefit.
- The use of animals should be minimized.
- Pain and distress should be minimized.

Most work with animals takes place within an academic or research setting. To receive funding and recognition for their work, institutions have to adhere to a code of ethics regarding their animal use. For example, the British Society of Animal Science's ethical guidelines for the use of animals in research experimentation refers to the 3 Rs.

- Refinement: any animal science research undertaken should be as focused as possible and have realistic and achievable aims of increasing knowledge of the species of interest in relation to our understanding of its functioning, performance, health or welfare. Researchers should avoid the causation of pain wherever possible but where there is deliberate infection of the animals, deliberate withholding of nutrition or genetic manipulation, then special justification must be made by the researcher.
- Replacement: researchers must consider all available options to replace animals with other techniques that will fulfill the research objectives. Researchers should always actively look for non-animal methods of investigation (e.g. computer models using statistical programs based on previous data).
- Reduction: there is a scientific, moral and legal requirement to expose as few animals to pain, suffering and distress as possible. Researchers should calculate how few animals are required to ensure they are able to obtain meaningful results. Furthermore, power calculations should be made to ensure that sample sizes in experiments are appropriate so as to not lead to wastage of animals and potential unnecessary suffering. Therefore, a statistician with expertise in experimental design should always be consulted before carrying out any experimental work.

Show an awareness of the specific ethical considerations related to animal research. They should be clearly labelled and supported with examples of good and bad practice. Show a practical awareness of how psychology research is carried out using animals.

The 3 Rs refers to Refinement, Reduction and Replacement and relate to a set of ethical guidelines written by the British Society of Animal Science.

TOK

Can animals be placed on an ethical hierarchy? Should animals with more human-like characteristics be more protected from harm? What ideologies can be used to create ethical frameworks?

To what extent does one's culture affect one's opinion toward using animals in research?

However, it could be argued that any animal with psychological and social abilities has the capacity to feel and understand pain. This raises philosophical questions about what rights animals should have in their interactions with humans.

## Activity

Find all of the new words or expressions from this chapter and write them into a document with their definitions and explanations next to them. Be creative and use diagrams or boxes to help make your personal glossary unique and effective.