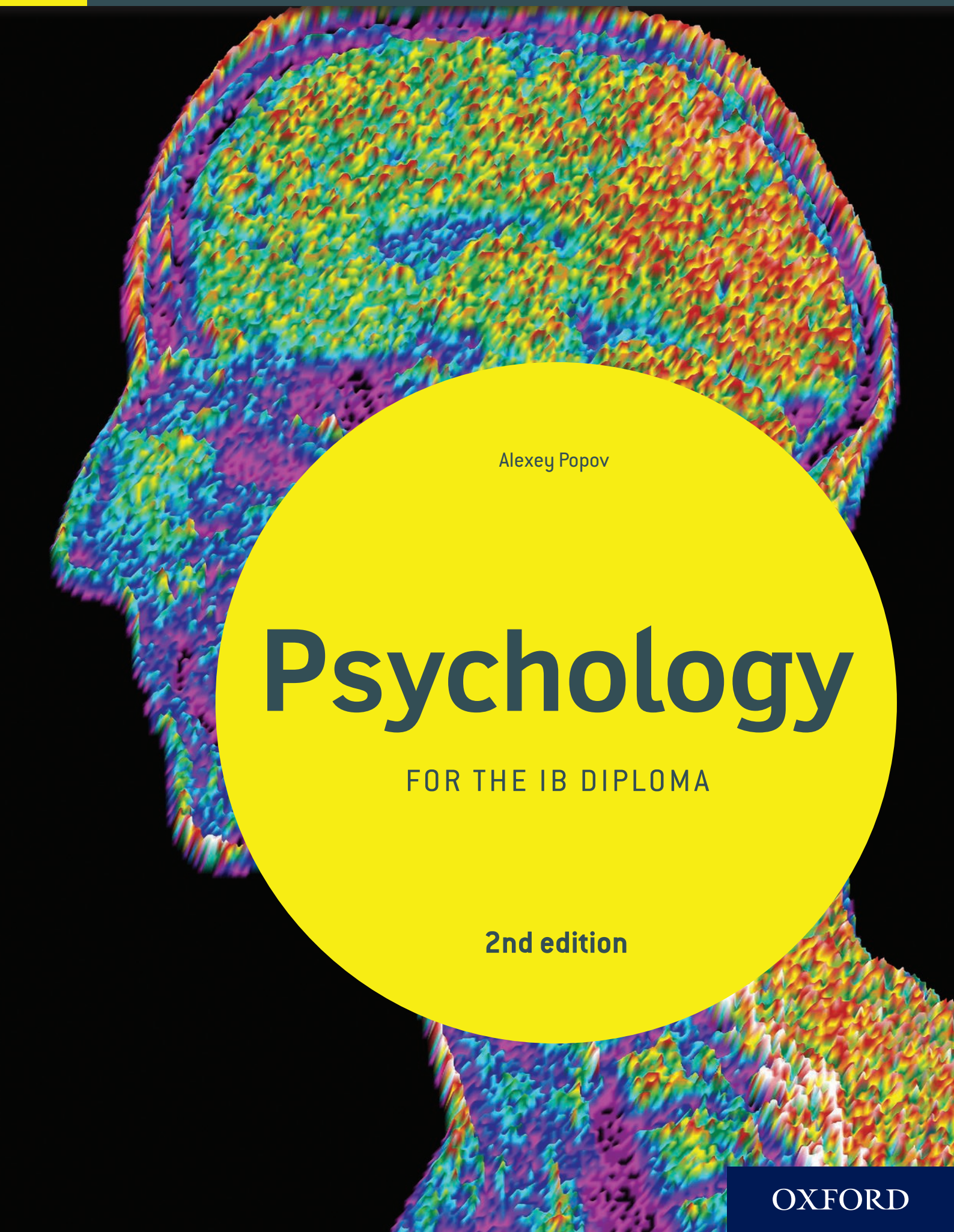
OXFORD IB STUDY GUIDES



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Psychology

FOR THE IB DIPLOMA

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Contents

The bibliography can be found at:
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Topics

1.1 Brain and behaviour

1.1.1 Localization

DEFINITIONS

- **Localization of function**—the theory that certain areas of the brain are responsible for certain psychological functions
- **Strict localization**—the idea that there is a clear correspondence between psychological functions and brain areas, and that all functions can be clearly mapped onto the brain
- **Weak localization**—the idea that one brain area may be responsible for a function, but not exclusively, and other areas may also take over the function
- **Widely distributed functions**—functions that cannot be localized anywhere in the brain

ESSENTIAL UNDERSTANDING

Strict localization

Research into localization of function has not been entirely conclusive. We do believe now that functions are localized, but the idea of strict localization has been gradually replaced by the belief that localization is relative.

The first research studies to support the idea of strict localization were based on patients with specific brain damage. The earliest localization phenomena that were thoroughly documented are Broca's aphasia and Wernicke's aphasia. See **"Broca's aphasia and Wernicke's aphasia"**.

This research inspired attempts to create comprehensive "brain maps". One such attempt belonged to Wilder Penfield (1891–1976), who used the method of neural stimulation to create his cortical homunculus (Penfield, Boldrey 1937). See **Wilder Penfield**.

Contrary to strict localization

There has, however, been research that opposed the idea of strict localization and even rejected the belief that some psychological functions may be localized anywhere in the brain. One such example is research by Karl Lashley (1929) who claimed that memory of a maze in rats was distributed rather than localized. See **Karl Lashley (1929)**.

Relative localization

Today's approach recognizes the concept of weak localization—the idea that several brain areas are responsible for the same function (and can potentially take over), but only one of these areas is dominant. An example of research supporting the idea that language (both production and comprehension) is weakly localized in the left hemisphere is split brain research conducted by Sperry (1968) and Gazzaniga (1967). See **Sperry (1968) and Gazzaniga (1967)**.

Looking at a larger variety of psychological functions, it can be claimed that psychological functions are relatively localized. See "**Relative localization of function**".

BROCA'S APHASIA AND WERNICKE'S APHASIA

Essential understanding

✪ *The first case studies used post-mortem examination of the brains of patients with unique speech disorders. Results of these studies inspired the idea of strict localization. It appeared that the production of articulate speech is localized in Broca's area, and speech comprehension in Wernicke's area.*

Paul Broca (1861) documented the case study of "Tan", a patient who lost the ability to speak or write but retained all other functions such as intelligence and speech comprehension. He understood everything said to him and tried to communicate back, but the only sound he could make was the syllable "tan". This condition, the loss of articulated speech, became known as Broca's aphasia. When Tan died, an autopsy was performed and it was discovered that his brain had a very specific lesion in the left hemisphere, in the posterior inferior frontal gyrus. This brain region is now known as Broca's area.

Shorty after that **Carl Wernicke (1874)** in similar case studies discovered the brain area responsible for comprehension of written and spoken language. Wernicke's area is located in the temporal lobe of the dominant hemisphere (usually the left). People with Wernicke's aphasia have an impairment of speech comprehension, but their articulate speech is intact.

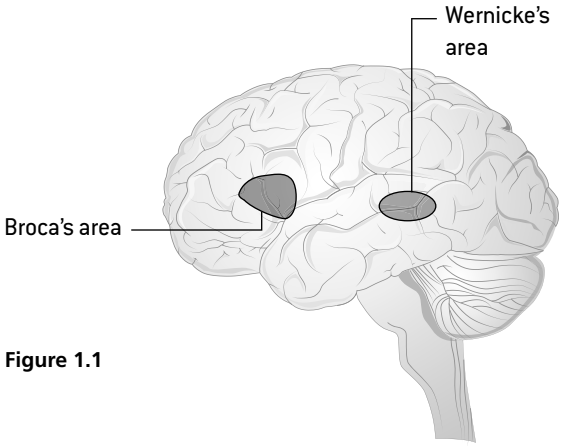

Figure 1.1

WILDER PENFIELD—MAPPING SENSORY AND MOTOR CORTEX

Essential understanding

✪ *Attempts to establish strict localization of function have culminated in the creation of cortical maps.*

Wilder Penfield used the method of neural stimulation—he stimulated various parts of the cortex with electrodes while the patient was awake and observed the effects this stimulation had on sensations and behaviour. Little by little he covered the whole cortex and created the cortical homunculus, a map that shows the relative representation of various parts of the body in the cortex (Penfield, Boldrey 1937).

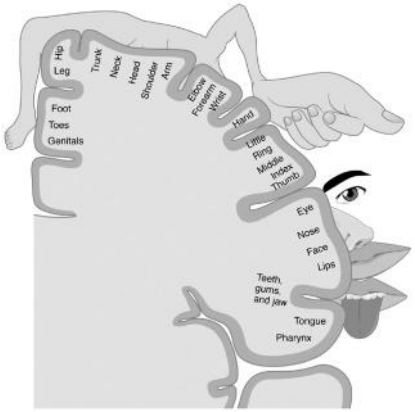

Figure 1.2 Cortical homunculus

RESEARCH Karl Lashley—some psychological functions are distributed rather than localized

Essential understanding

✪ *Experiments with induced brain damage in rats showed that memory is widely distributed rather than localized anywhere in the cortex.* ***Karl Lashley (1929)*** *used carefully controlled induced brain damage in the cortex of rats that were trained to run through a maze.*

Procedure

In a typical study, he trained a rat to go through a maze without mistakes in search of food, then removed a part of its cortex and observed what effect this would have on its memory of the maze. He removed 10–50% of the cortex on different trials.

Results

Results of these experiments did not support Lashley's original hypotheses and led him to formulate the following ideas.

- **The principle of mass action.** Memory of the maze depended on the percentage of cortex destroyed, but not on the location of the lesion.
- **Equipotentiality.** The idea that one part of the cortex can take over the functions of another part of the cortex when necessary.

Conclusion

Based on these observations Lashley concluded that memory is not localized; it is widely distributed across the cortex as a whole. Even if one part of the cortex is lost, other parts may take over the functions of the missing part.

RESEARCH **Sperry (1968) and Gazzaniga (1967)—research with split-brain patients**

Essential understanding

✪ *As demonstrated by split brain research, both production and comprehension of language are weakly localized (lateralized) in the left hemisphere.*

Aim

To investigate how the two hemispheres function independently when the connection between them is severed.

Participants

Four patients who underwent novel treatment for epilepsy that involved surgically cutting the corpus callosum.

Method

This was an in-depth case study of four unique individuals.

Procedure

A technique was used that allowed researchers to project stimuli to either the left or the right eye of the participant. They used a table with a board on it. Participants sat in front of the board, fixing their eyes on the dot in the centre. Stimuli were then flashed on the far right or the far left of the board for one-tenth of a second.

The idea was that since optic nerves from the right eye are connected in our brain to the left hemisphere and vice versa, the researchers could present stimuli to one of the hemispheres only.

For some trials the table also had a curtain with some objects behind it. Participants could reach behind the curtain and feel the objects with their hands.

Results

Multiple results were obtained in these studies; we will only mention some examples that illustrate the idea of relative localization of function.

- When a picture of a spoon was shown to the left visual field (connected to the right hemisphere) and participants were asked to describe the object, they said nothing. However, when asked to pick an object behind the curtain, they could feel around and pick a spoon but only with their left hand (because it is connected to the right hemisphere). Participants could not explain why they picked the spoon. This result supports the idea that language is localized in the left hemisphere—the right hemisphere saw the object and was able to tell the left hand what to do, but since language is localized in the left hemisphere, participants were not able to explain what they did and why.
- When a simple word (such as "pencil") was flashed to the right hemisphere, participants were able to reach behind the curtain and pick a pencil. This goes contrary to the previous finding and shows that the right hemisphere is able to process some simple speech. Perhaps while language production may be confined to the left hemisphere, language comprehension may be a function of both. This shows weak localization of language comprehension.
- When researchers placed four plastic letters in a pile behind the curtain and asked participants to "spell a word", one participant was able to spell "love" with his left hand. He was not able to name the word he just spelled. This shows that even language production, in some rudimentary form, may be present in the right hemisphere in some but not all people.

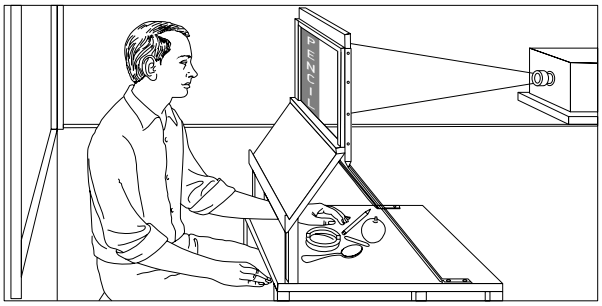

Figure 1.3 Visual test for split brain patients

Conclusion

These results support the idea that localization of language is not strict. Both language production and language comprehension are mostly localized in the left hemisphere, but the right hemisphere can also perform some simple tasks.

Note: Split brain studies are studies of lateralization—the division of functions between the left and the right hemisphere. Lateralization is a special case of localization, and if you explicitly acknowledge this, you can use Sperry's and Gazzaniga's research in answers to exam questions.

RELATIVE LOCALIZATION OF FUNCTION

Essential understanding

✪ *Localization of function is relative.*

The accumulated body of evidence suggests that localization of function in the human brain is relative. This idea of relative localization includes the following aspects.

- Some functions are indeed strictly localized. Examples include Broca's aphasia and Wernicke's aphasia.
- Some functions such as memory are widely distributed. Refer to Karl Lashley's research for an example.
- Some functions are weakly localized rather than strictly—several brain areas are responsible for the same function, but one of these areas is dominant. This is illustrated by split brain research, for example.
- Some components of a function may be localized while other components of the same function may be distributed. For example, speech production seems to be more localized than speech comprehension.
- Localization is not static: brain areas can respecialize due to neuroplasticity.

1.1.2 Neuroplasticity

DEFINITIONS

- **Cortical remapping—**neuroplasticity on the level of the cortex
- **Hippocampus—**a part of the limbic system, known to be implicated in emotional regulation and long-term memory
- **Neuroplasticity—**the ability of the brain to change itself in response to environmental demands
- **Synaptic plasticity—**neuroplasticity occurring on the level of a separate neuron, construction of new synaptic connections and elimination of the ones that are not used

ESSENTIAL UNDERSTANDING

Neuroplasticity is the ability of the brain to change through the making and breaking of synaptic connections between neurons. It occurs on different scales, from synaptic plasticity to cortical remapping.

The ability of the brain to remap its functions has been demonstrated in a study by Merzenich *et al* (1984). The study showed that cortical remapping of the fingers occurs in adult owl monkeys around two months after amputation. See **Merzenich *et al* (1984).**

Apart from the function of adapting to damage or injury, neuroplasticity is the biological mechanism of learning. Draganski *et al* (2004) showed that there was a structural change in the brain in response to a simple learning routine such as practising juggling periodically. See **Draganski *et al* (2004)**.

Maguire *et al* (2000) looked at human neuroplasticity in a natural setting and demonstrated that London taxi drivers experience significant changes in the relative distribution of grey matter in the hippocampus in response to the demands of the job. See **Maguire *et al* (2000)**.

RESEARCH **Merzenich *et al* (1984)—cortical remapping of digits in owl monkeys**

Essential understanding

✪ *The sensory cortex has the ability to remap its functions following an injury.*

Aim

To investigate how the sensory cortex responsible for the hand will respond to injury.

Participants

Eight adult owl monkeys.

Method

Experiment; repeated measures design.

Procedure

Sensory inputs from all the hand digits (fingers) were mapped in the cortex. To do this, electrodes were attached to the part of the cortex known to be responsible for sensations from the hand, then different fingers were stimulated. It was noted which of the electrodes respond to the stimulation.

One or several digits on the monkey's hand were amputated. A remapping was done 62 days after the amputation to see how the cortex adapted to the injury.

Results

The first mapping showed that there were five distinct areas in the cortex, each responsible for one digit. Adjacent fingers were represented by adjacent areas in the cortex.

Post amputation, the now unused area of the sensory cortex was occupied by adjacent intact fingers. For example, if digit 3 had been amputated, the cortical areas for digits 2 and 4 spread and "consumed" the cortical area previously responsible for digit 3.

Conclusion

The sensory cortex of adult owl monkeys adapts to injury by cortical remapping.

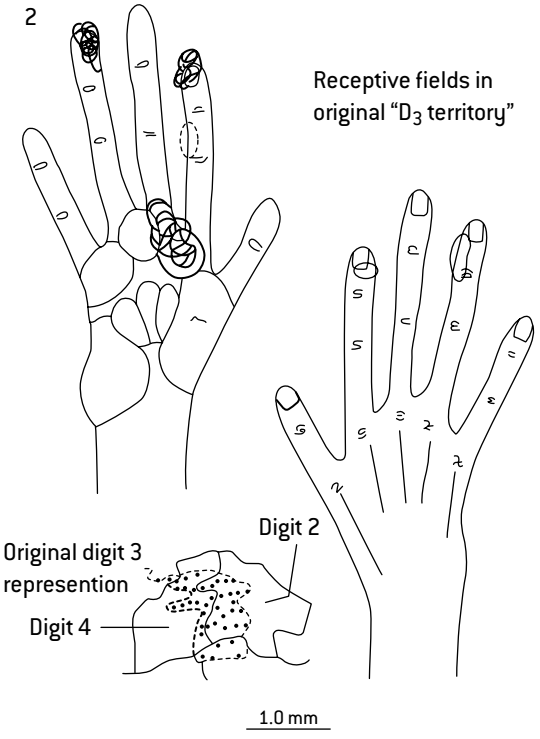

Figure 1.4 Cortical remapping after digit amputation

RESEARCH **Draganski *et al* (2004)—structural changes in the brain in response to juggling**

Essential understanding

✪ *Neuroplasticity occurs in response to regular learning practices, which suggests that neuroplasticity is the neural basis of learning.*

Aim

To investigate whether structural changes in the brain would occur in response to practising a simple juggling routine.

Participants

A self-selected sample of volunteers with no prior experience of juggling.

Method

Experiment; mixed design.

Procedure

The sample was randomly divided into two groups: jugglers and non-jugglers. Jugglers spent three months learning a classic juggling routine with three balls followed by three months in which they were instructed to stop practising. Participants in the control group never practised juggling.

Three brain scans (MRI) were performed in both groups: one before the start of the experiment, one after three months, one after six months.

Results

There were no differences in brain structure between jugglers and non-jugglers before the experiment.

After three months of practice, the jugglers had significantly more grey matter in the mid-temporal area of the cortex in both hemispheres. These areas are known to be responsible for coordination of movement.

After six months (that is, three months of non-practice) the differences decreased. However, the jugglers still had more grey matter in these areas than at the first brain scan.

Conclusion

Grey matter grows in the brain in response to environmental demands (learning) and shrinks in the absence of stimulation (lack of practice). This shows that there is cause-and-effect relationship between learning and brain structure.

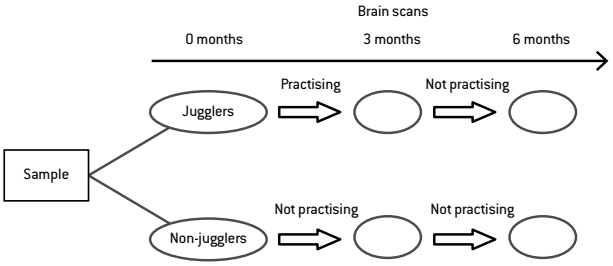

Figure 1.5

RESEARCH **Maguire *et al* (2000)—neuroplasticity in London taxi drivers**

Essential understanding

✪ *Neuroplasticity occurs in natural settings. Redistribution of grey matter in the hippocampus is observed in taxi drivers as a function of their driving experience.*

Aim

To investigate how the brain structure of London taxi drivers is different from the average brain.

Participants

16 right-handed male taxi drivers. The average experience as a taxi driver was 14.3 years.

A control group: 50 healthy right-handed male subjects who did not drive a taxi.

Method

Quasi-experiment (comparison of two pre-existing groups); correlational study in the part where driving experience was correlated with grey matter volume. MRI was used to measure the variables.

Procedure

MRI scans were compared between drivers and non-drivers.

Researchers also correlated the number of years of taxi driving experience with results of the MRI scans.

Results

Taxi drivers had increased grey matter volume in the posterior hippocampus, compared to the control group subjects. On the other hand, control subjects had increased grey matter volume in the anterior hippocampus.

A correlation was observed between the number of years of taxi driving experience and grey matter volume in the hippocampus: the longer they drove a taxi, the larger the volume of their posterior hippocampus. The opposite was true for anterior hippocampus.

This means that redistribution of grey matter occurred in the hippocampus of taxi drivers, from the anterior to the posterior.

Conclusion

Redistribution of grey matter in the hippocampus occurs in taxi drivers in response to gaining navigational experience.

The posterior hippocampus is known to be involved in using previously learned spatial information, while the anterior hippocampus is known to be responsible for learning new spatial information.

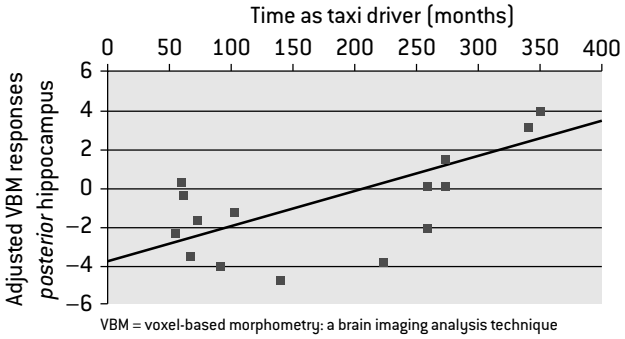

Figure 1.6 Hippocampal volume and amount of time as a taxi driver

1.1.3 Neurotransmitters and behaviour

DEFINITIONS

- **Agonist—**a chemical that enhances the action of a neurotransmitter
- **Antagonist—**a chemical that inhibits the action of a neurotransmitter
- **Neurotransmitter—**a chemical messenger stored in the axon and released into the synaptic gap
- **Selective serotonin reuptake inhibitors (SSRIs)—**a class of chemicals that act by preventing reuptake of excess serotonin in the synapse, hence increasing its concentration in the synaptic gap

ESSENTIAL UNDERSTANDING

The nature of information transmission in the nervous system is both electrical and chemical. The chemical part of the process is enabled by neurotransmitters. See **"Nervous system processes"**.

Neurotransmission affects a wide range of behaviours.

Crockett *et al* (2010) demonstrated the effect of serotonin on prosocial behaviour. They found that increased levels of serotonin cause people to be more opposed to the idea of inflicting harm on someone, promoting prosocial behaviour and making it less likely for participants to justify aggression. See **Crockett *et al* (2010)**.

Freed *et al* (2001) investigated the role of dopamine in Parkinson's disease. They showed that transplantation of dopamine-producing cells into the putamen of patients with severe symptoms of Parkinson's could lead to a 28% reduction in symptoms. See **Freed *et al* (2001)**.

Fisher, Aron and Brown (2005) demonstrated that dopamine may be implicated in feelings of romantic love. See **Fisher, Aron and Brown (2005)**.

We need to be aware that research which attempts to isolate the effect of one neurotransmitter is inevitably oversimplified. See **"Limitations in neurotransmitter research"**.

NERVOUS SYSTEM PROCESSES

Essential understanding

✪ *The nature of information transmission in the nervous system is both chemical and electrical. Neurotransmitters are chemical messengers that are released in the synaptic gap. They are affected by a variety of chemicals: agonists and antagonists.*

Neurons

The nervous system is a system of neurons. A neuron consists of three parts: the body, dendrites and the axon. Where the axon of one neuron approaches another neuron, a synapse is formed.

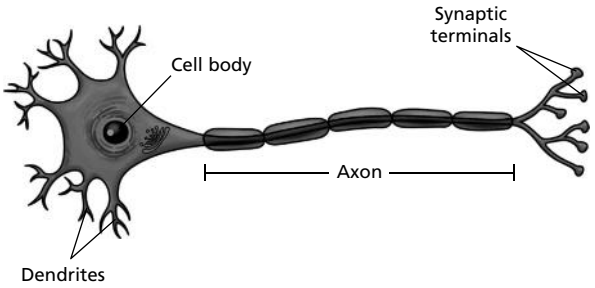

Figure 1.7 A neuron

Information transmission

The nature of information transmission in the nervous system is partly electrical and partly chemical. An electrical impulse builds up at the synapse and travels across the neuron and its axon, passing the excitation on to the next synapse.

At the synapse the mechanism becomes chemical. When the electrical impulse reaches the end of the axon, a neurotransmitter is released into the synaptic gap. This neurotransmitter can then:

- be pulled back into the axon that released it (this process is called reuptake)
- reach the end of the synaptic gap and bind itself to one of the receptors on the surface of the next neuron.

When the neurotransmitter binds to a receptor, this changes the next neuron's electric potential and contributes to building up the impulse.

Agonists and antagonists

Neurotransmitters themselves are affected by certain chemicals: agonists and antagonists. Agonists act by enhancing the action of neurotransmitters and antagonists counteract neurotransmitters. For example, some of the widely used antidepressants are SSRIs (selective serotonin reuptake inhibitors). They act as agonists for the neurotransmitter serotonin; they inhibit its reuptake thus increasing its concentration in the synapse.

RESEARCH Crockett *et al* (2010)—the effect of serotonin on prosocial behaviour

Essential understanding

✪ *Neurotransmitters affect not only behaviours that are obviously biologically based (such as mood or fatigue), but also behaviours that seem to be the result of free will, such as prosocial acts.*

Aim

To investigate the effect of serotonin on prosocial behaviour.

Participants

30 healthy volunteers.

Method

Experiment; repeated measures design. The design was counterbalanced. The study was double-blind.

Procedure

In condition 1 participants were given a dose of citalopram (an SSRI). In condition 2 they were given a placebo.

Participants were given moral dilemmas based on the classic "trolley problem": there is a runaway trolley moving along the tracks and you see that it is about to hit and kill five people; you have a choice between doing nothing and interfering.

- **In impersonal scenarios** interfering implied pulling a lever that diverts the trolley onto another track where it kills one person.
- **In personal scenarios** interfering implied pushing a man on the tracks, so that the man's body will slow down the trolley and prevent it from hitting the five workers.

In both these scenarios the choice is between killing one person or letting five people die, but in the personal scenario killing is a more direct and emotionally aversive act.

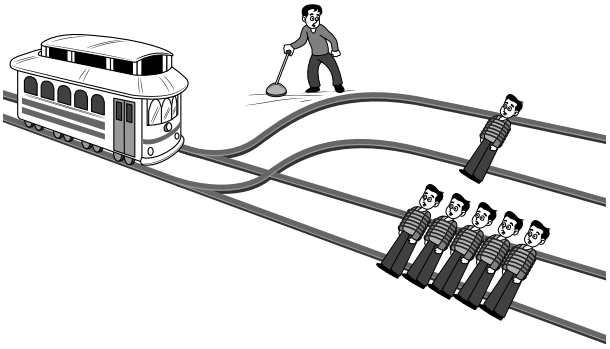

Figure 1.8 The trolley problem

Results

In the impersonal scenario participants' responses were unaffected by citalopram. In the personal scenario citalopram made participants less likely to interfere (that is, less likely to push the man off the bridge).

Conclusion

Citalopram reduces the acceptability of personal harm and in this sense promotes prosocial behaviour. Increased levels of serotonin in the brain may cause people to be more opposed to the idea of inflicting harm on someone.

RESEARCH **Freed *et al* (2001)—the role of dopamine in Parkinson's disease**

Essential understanding

✪ *Dopamine at least partially affects symptoms of Parkinson's disease, especially in younger patients.*

Aim

To investigate the effects of dopamine on the behavioural symptoms of Parkinson's disease.

Participants

40 patients with severe Parkinson's disease. The mean duration of the disease was 14 years and ages ranged from 34 to 75 years.

Method

Experiment; independent measures design.

Procedure

In the experimental group nerve cells containing dopamine-producing neurons were taken from aborted embryos and transplanted into the patient's putamen. Four holes were drilled through the skull and the tissue was transplanted through long needles.

The control group underwent sham surgery: holes were drilled in the skull but the tissue was not transplanted.

All patients were followed for one year. PET scans were made to estimate changes in the brain; clinical observations and interviews were used to register changes in symptoms.

Results

PET scans revealed significant growth of dopamine-producing cells in the putamen of participants in the transplant group. Patients in the transplant group demonstrated a reduction of Parkinson's symptoms by 28%, but only in the relatively younger group (below 60).

Conclusion

Transplantation of dopamine-producing neurons in the putamen of patients with severe symptoms of Parkinson's disease leads to an improvement in younger but not older patients. This shows the influence of dopamine on behaviour.

RESEARCH **Fisher, Aron and Brown (2005)—dopamine and romantic love**

Essential understanding

✪ *Dopaminergic activity may be the biological basis of romantic love.*

Aim

To investigate neural mechanisms of romantic love.

Participants

17 participants who were "intensely in love" with someone, mean age 21 and mean duration of being in love 7 months.

Method

Experiment; repeated measures design. Variables were measured in fMRI scans.

Procedure

Participants were placed in a fMRI scanner and went through the following four steps, which were repeated six times:

- viewing a photograph of the person they love—30 seconds
- filler activity—40 seconds
- viewing a photograph of an emotionally neutral acquaintance—30 seconds
- filler activity—20 seconds.

Brain responses to the picture of a loved one and to the picture of a neutral acquaintance were compared.

Results

There was a specific pattern of activation in the brain in response to the photographs of the loved ones. Activation was especially prominent in dopamine-rich brain areas.

Conclusion

Dopaminergic activity plays a role in feelings of romantic love.

LIMITATIONS OF NEUROTRANSMITTER RESEARCH

Essential understanding

✪ *Research that attempts to isolate the effect of one neurotransmitter is inevitably oversimplified. However, it leads to important insights.*

Neurotransmission is a complex process. There are more than 100 known neurotransmitters, and each of them has multiple effects on behaviour. Neurotransmitters in the synaptic gap affect each other and, on top of that, are affected by agonists and antagonists.

When it comes to research, however, we typically increase the level of one isolated neurotransmitter (X) and observe the changes in behaviour (Z). Can we say that X influences Z? Yes, but with the following limitations.

- The effect may be indirect. For example, X acts as an agonist for neurotransmitter Y, and it is Y that influences Z.
- The effect may be postponed. For example, X triggers a long-lasting process of change in interconnected variables, ultimately resulting in Z.
- X may not be the only factor affecting Z.
- X is never the only factor that changes: when we increase the level of X, this results in various side effects.

1.1.4 Techniques used to study the brain in relation to behaviour

DEFINITIONS

- **BOLD (blood-oxygen-level dependent) signal**—pulses of energy emitted by oxygenated blood when placed in an external magnetic field, used in fMRI
- **Spatial resolution**—the ability of a scanner to discriminate between nearby locations, a unit of space that is discernable in a brain scan
- **Temporal resolution**—the smallest time period in which a brain scan can register changes in the brain

ESSENTIAL UNDERSTANDING

For a long time, brain research was limited to conducting post-mortem autopsies on patients with unusual behavioural deviations (such as Broca's and Wernicke's patients). After the invention of brain imaging techniques it was possible to study the human brain non-invasively.

The most commonly used brain imaging techniques are:
- computerized axial tomography (CAT)
- positron emission tomography (PET)
- magnetic resonance imaging (MRI)
- functional magnetic resonance imaging (fMRI)
- electroencephalography (EEG).

The choice of brain imaging techniques is full of trade-offs, such as structure versus process, spatial resolution versus temporal resolution, amount of detail and time of the scanning procedure, and so on. See **"Comparison of brain imaging techniques"**.

Examples of research studies that used brain imaging technology can be found in other sections and other units. A few examples from this unit are: Draganski *et al* (2004), Maguire *et al* (2000), Freed *et al* (2001), Fisher, Aron and Brown (2005). See **"Examples of research using brain imaging techniques"**.

COMPUTERIZED AXIAL TOMOGRAPHY (CAT)

Principle of work
When an X-ray passes through the head, it is picked up by a detector on the opposite side and analysed. Since bone and hard tissue absorb X-rays better than soft tissue (such as nervous cells), analysis of the residual rays can reveal information about brain structure.

Procedure
The subject lies on a table that slides into a large cylindrical apparatus. The apparatus produces a moving source of X-rays that pass through the subject's head.

Strengths
This is a quick and non-invasive method of studying brain structure. Since it does not use magnetic fields, CAT can be used with people who have medical implants.

Limitations
There is some level of radiation exposure.

MAGNETIC RESONANCE IMAGING (MRI)

Principle of work
When placed in an external magnetic field, some atomic nuclei (for example, those of hydrogen) can emit energy. These pulses of energy can be detected. Since we know that the concentration of hydrogen differs in different types of tissue, we can use this information to produce a three-dimensional picture of brain structure.

Procedure
Similar to CAT, the subject is placed on a table that slides inside a cylindrical apparatus.

Strengths
There is no radiation exposure. MRI has a better spatial resolution than CAT.

Limitations
Due to its high resolution, the scanner sometimes picks up slight abnormalities in the brain that are not related to the original complaint. This may create anxiety and cause people to pursue unnecessary treatment. Due to the strong magnetic fields, people with metal in their body cannot undergo the procedure. Being placed in a narrow tube for a long time may be an issue for people suffering from claustrophobia. This may be difficult for young children. Furthermore, MRI scans are expensive.

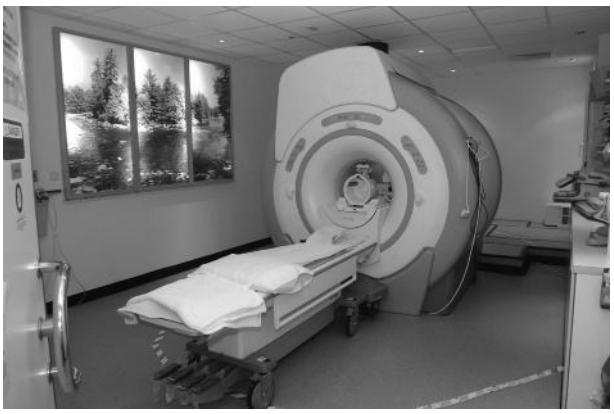

Figure 1.9 MRI machine

FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI)

Principle of work
This method uses the BOLD (blood-oxygen-level dependent) signal. When a brain region is active during the performance of a task, the organism supplies it with oxygenated blood. When oxygenated blood is placed in an external magnetic field, it emits pulses of energy, but this response depends on the blood flow and level of oxygenation. Since we know that the most active brain areas are supplied with the most blood, this also allows us to see which brain areas are most active during the performance of a particular task.

Procedure
Similar to MRI, but subjects are also required to carry out a task while their brain is being scanned.

Strengths
Unlike MRI and CAT that can only be used to map brain structure, fMRI also shows ongoing brain processes. It produces excellent spatial resolution.

Limitations
It is necessary to discriminate between systematic patterns of activation and random noise. Some sources of noise include head movements, fidgeting and random thoughts. Eliminating noise requires a lengthy experimental procedure with many trials.

Temporal resolution is around 1 second, which means that only relatively long-lasting processes can be studied.

POSITRON EMISSION TOMOGRAPHY (PET)

Principle of work
A radioactive tracer is injected in the subject's bloodstream. This tracer binds to molecules such as glucose. It decays quickly and emits energy. The more active a brain area, the more blood supply it needs, hence the higher the energy level emitted by the tracer.

Procedure
After the injection the subject is placed in a scanner that picks up the energy emissions.

Strengths
Like fMRI, this shows both the structure and the processes in the brain. It provides good spatial resolution, and the scanner can be small and even portable.

Limitations
There is exposure to radioactivity and it provides poor temporal resolution (as compared to fMRI), so only relatively slow processes can be registered.

ELECTROENCEPHALOGRAPHY (EEG)

Principle of work
When large groups of neurons are activated simultaneously, electric potentials generated by these impulses become detectable on the skull surface. Electrodes can be attached to the scalp to detect this electrical activity.

Procedure
Electrodes are attached to the scalp at predetermined points. The subject is required to lie still for several minutes while the electroencephalogram is generated.

Strengths
This provides perfect temporal resolution—changes in the electric potentials are detected within milliseconds. It is useful in diagnosing such conditions as epilepsy or sleep disorders, and is cheap, mobile, silent and non-invasive.

Limitations
It provides poor spatial resolution—the origin of the signal cannot be established. It is only good for detecting changes in the overall patterns of brain activity. It is useful for detecting electrical activity in the cortex, but the signal from subcortical areas is too weak to be registered on the surface of the scalp.

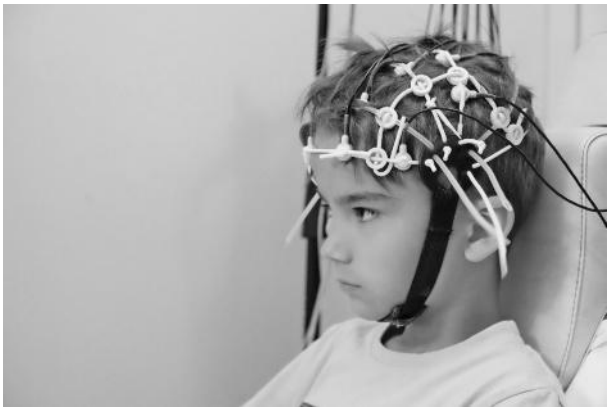

Figure 1.10 EEG machine in use

COMPARISON OF BRAIN IMAGING TECHNIQUES

Essential understanding

✪ *Choosing between the techniques is not easy. It is determined by a number of trade-offs and criteria such as structure versus process, spatial and temporal resolution, and artificiality and cost of the procedure.*

The first important distinction is between structure and process. Some techniques are used to produce a three-dimensional image of brain structure. Other techniques are used to detect patterns of brain activity. They can be used to study brain response to performing task A in comparison to performing task B.

Once this is decided, you need to choose your desirable spatial and temporal resolution. There is a certain trade-off involved. Higher spatial resolution means a longer scanning time. It can be problematic in some cases. Every imaging technique has a threshold of spatial and temporal resolution above which it cannot go. Excellent temporal resolution comes at the cost of low spatial resolution.

Finally, there is the scanning procedure. One needs to take into account the cost and influence on the participant.

All brain imaging techniques, however, have a major advantage over post-mortem examination: they allow us to study the living brain in a non-invasive way.

Criteria	MRI	CAT	fMRI	PET	EEG
Structure or process?	Structure	Structure	Process	Process	Process
Spatial resolution	Up to 1–2 mm	Up to 1–2 mm	Up to 1–2 mm	4 mm	Very poor
Temporal resolution	Not applicable	Not applicable	1 second	30–40 seconds	Milliseconds
Major advantage for research	Gives a detailed three-dimensional image of the brain	Lower cost; used more and more rarely as MRIs become cheaper	Shows patterns of brain activation while performing a task	Portable; less artifacts associated with the scanning procedure	Detects very quick changes in the patterns of cortical activity ("brain waves")

Table 1.1 Summary of brain imaging techniques

EXAMPLES OF RESEARCH USING BRAIN IMAGING TECHNIQUES

Examples of such research studies can be found throughout the course in various units. Here are a few examples from this unit.

Study	Brain imaging technique	Aim
Draganski *et al* (2004)	MRI	To investigate changes in grey matter volume as a result of practising a simple juggling routine
Maguire *et al* (2000)	MRI	To compare brain structure in people with extensive navigational skills (London taxi drivers) and controls
Freed *et al* (2001)	PET	To investigate if dopamine has any role on behavioural symptoms of Parkinson's disease, by transplanting dopamine-producing tissue to the putamen of patients with severe Parkinson's disease
Fisher, Aron and Brown (2005)	fMRI	To investigate which areas of the brain are activated when participants look at pictures of people they love, and to study the role of dopamine in feelings of romantic love

Table 1.2

1.2 Hormones and pheromones and behaviour

1.2.1 The influence of hormones on behaviour

DEFINITIONS

- **Endocrine system—**a chemical messenger system of the organism; the system of glands that secrete hormones
- **Gene knockout (KO)—**a genetic technique in which one of the genes of an organism is "switched off"; the term can also be used to describe the organism that carries this inoperative gene
- **Oxytocin—**a hormone produced by the hypothalamus and released by the pituitary gland; it is known for its role in social interaction and sexual reproduction

ESSENTIAL UNDERSTANDING

Like neurotransmitters, hormones are chemical messengers. However, their mechanism of action is different. They are released into the bloodstream and regulate relatively slower processes. See "**Comparison of hormones and neurotransmitters**".

There are many different hormones, but we will focus on the role of oxytocin, a hormone known as "the love hormone". See **"Oxytocin"**.

Ferguson *et al* (2000) observed that when the oxytocin gene in mice is switched off, it prevents them from recognizing familiar social stimuli. This may be potentially helpful in understanding what causes autism in humans. See **Ferguson *et al* (2000)**.

Scheele *et al* (2012) tested if oxytocin would have an effect on a man's willingness to approach an attractive woman if the man is in a stable relationship. They found that this approach behaviour is inhibited in men who are in a stable relationship (but not single men) when they are given a dose of oxytocin (but not placebo). This suggests that oxytocin plays a role in human fidelity. See **Scheele *et al* (2012)**.

COMPARISON OF HORMONES AND NEUROTRANSMITTERS

Essential understanding

✪ *Unlike neurotransmitters, hormones are released into the bloodstream and regulate relatively slower processes.*

The function of hormones differs from the function of neurotransmitters in several ways.

	Neurotransmitters	Hormones
What means of communication are used?	The nervous system	The system of blood vessels (hormones are released into the bloodstream)
What processes are regulated?	Relatively rapid processes such as emotions, decisions, attention and so on	Relatively slow processes such as growth, metabolism, digestion or reproduction

Table 1.3

Hormones are released by endocrine glands such as adrenal glands, the hypothalamus or pancreas. Together all these glands are known as the endocrine system.

There is a large variety of hormones produced in the body. Examples include adrenaline, noradrenaline, cortisol, oxytocin, insulin, testosterone and oestrogen.

OXYTOCIN

Oxytocin is released by the pituitary gland. It plays a role in sexual reproduction, childbirth and social bonding, which is why it has been given such labels as "the love hormone" and "the cuddle chemical". It is also released during breastfeeding, which plays a role in establishing the bond between the mother and the child.

RESEARCH Ferguson *et al* (2000)—social amnesia in mice lacking the oxytocin gene

Essential understanding

✪ *When the oxytocin gene in mice is switched off, it prevents them from recognizing familiar social stimuli. This may be potentially helpful in understanding what causes autism in humans.*

Background

Social familiarity in rodents is based on olfactory cues. If a rodent repeatedly meets another member of the same species, the olfactory investigation time (time spent sniffing the other animal on meeting it) decreases.

Aim

To investigate the role of oxytocin in social memory in rodents.

Participants

42 oxytocin gene knockout mice and 42 mice with normal genotype. All mice were male.

Method

Experiment; mixed design (independent measures and repeated measures).

Procedure

A female mouse was introduced into the home cage of the "participant" for a one-minute confrontation. This was repeated four times with ten-minute intervals between trials. These were called "habituation trials". The same mouse was used on all four trials. On the fifth trial (dishabituation) a new female mouse was introduced.

Behaviour was recorded and scored by trained raters. Olfactory investigation was operationalized as the amount of time spent in nasal contact with the female mouse.

Results

Mice with normal genotype showed considerable habituation from the first trial to the fourth. The amount of time they spent in olfactory contact with the female mouse decreased on each subsequent trial. On the fifth trial (when the new female mouse was introduced) dishabituation occurred and the amount of time in olfactory contact returned to the original level.

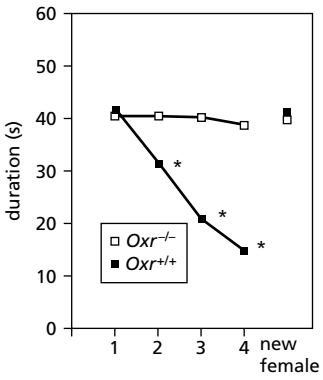

Figure 1.11 Results of Ferguson *et al* (2000)

Oxytocin gene knockout mice showed no habituation. They spent equal time in olfactory contact with the female mouse each time she was placed in the cage.

Conclusion

Oxytocin is necessary for the development of social memory in mice. It plays a role in recognizing familiar members of the same species.

Notes: In terms of its application to humans, results of this research could be useful for the development of new treatments for autism. Although not directly about autism, this study suggests that oxytocin levels may be responsible for reacting to social cues, which is one of the deficits in people suffering from disorders of the autistic spectrum (Modi, Young 2012).

RESEARCH Scheele *et al* (2012)—the role of oxytocin in human fidelity

Essential understanding

✪ *Oxytocin modulates social distance between men and women.*

Aim

To investigate the role of oxytocin in promoting fidelity in humans.

Participants

86 heterosexual men, some single and some in a stable relationship.

Method

Experiment; independent measures design; double blind study.

Procedure

Either oxytocin or placebo was administered to the participants intranasally. After this, participants were required to engage in two tasks.

1. Stop-distance paradigm—the participant stood at one end of the room; an attractive female confederate stood at the other end. Participants were instructed to slowly approach the female confederate and stop at a distance that made them feel slightly uncomfortable.

2. Approach/avoidance task—participants were positioned in front of a screen. They also had a joystick. They were then shown a series of pictures of four types, in random order:

- positive social pictures (such as attractive women)
- positive non-social pictures (such as beautiful landscapes)
- negative social pictures (such as mutilations)
- negative non-social pictures (such as dirt).

If the participant liked the picture, he had to pull the joystick, increasing the size of the picture. If he did not like the picture, he had to push the joystick, making the picture smaller.

Results

Results of the first task showed that oxytocin caused men to keep a greater distance from the attractive female confederate, but only if the man was in a stable relationship.

Results of the second task showed that the only group of pictures affected by oxytocin and relationship status was the positive social group (pictures of attractive women). Men in a relationship (but not single men) pulled the joystick more slowly in the oxytocin condition but not in the placebo condition.

Conclusion

Oxytocin causes men in a relationship to keep a greater distance from attractive women who are not their partner. Researchers explained that this promotes fidelity.

The second task makes it evident that this effect of oxytocin is highly specific and selective to a certain group of stimuli: attractive women.

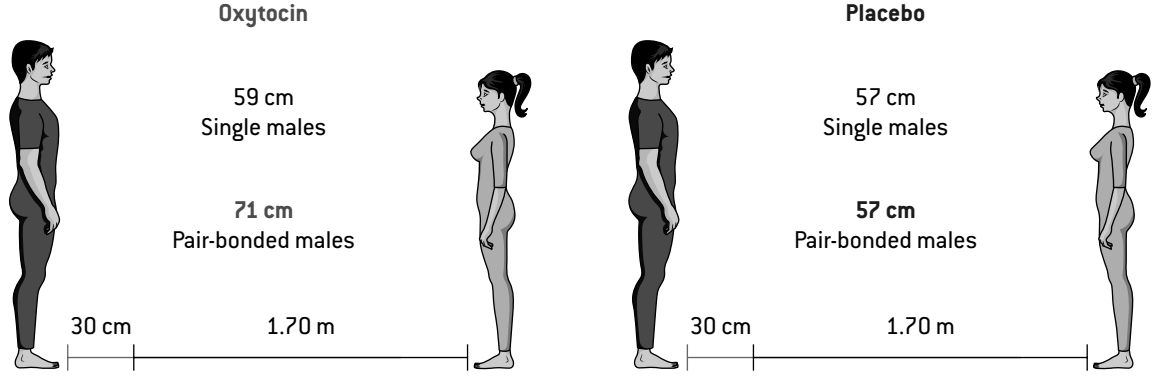

Figure 1.12 The stop-distance paradigm

1.2.2 The influence of pheromones on behaviour

DEFINITIONS

- **Pheromone—**a chemical messenger that communicates information (such as fertility or sexual attractiveness) from one member of a species to another
- **Putative human pheromone—**a chemical substance that is hypothesized to be a human pheromone such as androstadienone (AND) and estratetraenol (EST)

ESSENTIAL UNDERSTANDING

Pheromones are chemical messengers that communicate information from one member of a species to another. They are processed in the accessory olfactory bulb in animals, but whether or not there exists a biological mechanism to process pheromones in humans is unclear. See **"Biology of pheromones"**.

The search for human pheromones has taken the form of both laboratory and field experiments.

For example, Lundstrom and Olsson (2005) in an experimental procedure showed that androstadienone (AND) increased the mood of female participants if the study was carried out by a male, but not a female experimenter. This seems to suggest that androstadienone can modulate women's emotional reaction to men, indicating its possible function as a human pheromone. See **Lundstrom and Olsson (2005)**.

On the other hand, Hare *et al* (2017) in a carefully designed experimental procedure demonstrated that neither AND (androstadienone) nor EST (estratetraenol) could signal gender or attractiveness. Since these are the basic functions a human pheromone must be able to perform, these results bring into question the status of these chemicals as putative human pheromones. See **Hare *et al* (2017)**.

In a field experiment, Cutler, Friedman and McCoy (1998) showed that a synthetic human pheromone applied to aftershave cream increased the attractiveness of men to women, which resulted in a higher incidence of sexual behaviours. See **Cutler, Friedman and McCoy (1998)**.

These research studies, however, only serve as examples of laboratory and field experiments in this area. Summarizing all available research, it must be concluded for the time being that research has been contradictory and inconclusive, and the human pheromone has not been found. See **"Criticism of human pheromone research"**.

BIOLOGY OF PHEROMONES

Essential understanding

✪ *Pheromones are chemicals that signal information (such as fertility or sexual attractiveness) from one member of a species to another. While pheromones are important for communication in various species, including mammals, their role in humans is debatable.*

Pheromones are chemical messengers

Pheromones are chemicals that provide chemical communication between members of the same species. In this way, just like neurotransmitters and hormones, they are chemical messengers. However, unlike the other chemical messengers, pheromones communicate information from one species member to another.

An example of information that is communicated by pheromones is female fertility. Such pheromones have been shown to play an important role in the sexual behaviour of a number of species including many mammals.

Where in the brain are pheromones processed?

Mammals have a structure called the **vomeronasal organ (VNO)** located in their nasal cavity. This structure is connected through nerves to the brain region called the **accessory olfactory bulb**. This region is adjacent to, but separate from, the brain area responsible for processing regular smells, the **main olfactory bulb**.

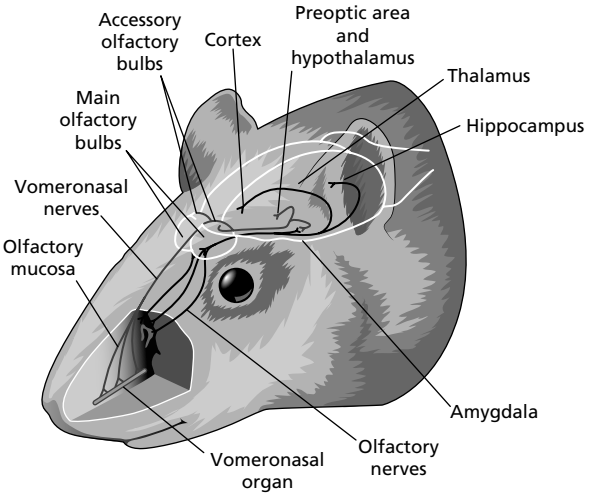

Figure 1.13 Biology of pheromone processing

Processing pheromonal information in the human brain

Human fetuses have the accessory olfactory bulb, but it regresses and disappears after birth. As for the VNO, some people have it and some don't. Even in those people who do have it, it appears to be disconnected from the nervous system. However, there is still a possibility that pheromonal information in humans is processed elsewhere.

Two chemicals that have been extensively studied as putative human pheromones are androstadienone (AND) and estratetraenol (EST).

RESEARCH **Lundstrom and Olsson (2005)—effects of androstadienone on women's attraction to men**

Essential understanding

✪ *Being exposed to androstadienone increases the mood of women in the presence of a male experimenter, which suggests that this chemical may trigger attraction.*

Aim

To investigate the effect of androstadienone on the mood of women in the presence of men.

Participants

37 heterosexual women, mean age 25 years, with a normal menstrual cycle.

Method

Experiment; 2 x 2 experimental design (two independent variables with two levels each).

Procedure

Female participants' mood was studied in a 2 x 2 experimental design. They were assessed after being exposed to either androstadienone or a control solution, and in the presence of either a male or a female experimenter.

The experimenter carried out a number of measurements including several questionnaires. One of the questionnaires measured participants' mood.

The experimenter was either female (age 28) or male (age 30).

Results

Androstadienone increased women's mood in the presence of a male experimenter, but not a female experimenter.

Conclusion

Androstadienone may serve the function of signaling sexual attractiveness, which supports its role as a pheromone.

RESEARCH **Hare *et al* (2017)—the ability of androstadienone and estratetraenol to signal gender and attractiveness**

Essential understanding

✪ *Any chemical that is hypothesized to be a human pheromone signaling sexual attractiveness must be able to perform two functions: 1) signal gender and 2) affect perceived attractiveness of the faces of the opposite sex. Hare et al's research showed that neither AND nor EST perform either of these functions, which brings into question their status as human pheromones.*

Aim

To investigate if androstadienone (AND) and estratetraenol (EST) signal gender and affect mate perception.

Participants

140 heterosexual adults.

Method

Experiment; repeated measures design.

Procedure

Participants completed two computer-based tasks on two consecutive days. On one of the days they were exposed to the putative pheromone (AND or EST) masked with clove oil; on the other day they were exposed to the control scent (clove oil alone). The order of conditions was counterbalanced.

In the first task, participants were shown five "gender-neutral facial morphs" and had to indicate the gender (male or female).

In the second task they were shown photographs of individuals of the opposite sex and asked to rate their attractiveness on a scale from 1 to 10.

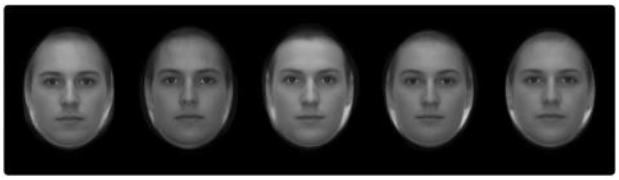

Figure 1.14 Gender-neutral facial morphs

Results

There was no difference in gender assigned to the morphed faces in the pheromone versus control condition. There was no difference in the average attractiveness ratings of the photographs of the opposite sex.

Conclusion

The two chemicals (AND and EST) do not act as signals of gender or of attractiveness. Based on this result, researchers concluded that these chemicals do not qualify as human pheromones.

RESEARCH **Cutler, Friedman and McCoy (1998)—a field experiment with a synthetic human pheromone**

Essential understanding

✪ *In a field experiment, researchers showed that a synthetic human pheromone applied to a man's aftershave lotion increased the incidence of behaviours that seemed to suggest sexual contact initiated by women. From this, researchers concluded that pheromones may increase sexual attractiveness of men to women.*

Aim
To investigate if a synthesized human pheromone can increase sociosexual behaviour of men.

Participants
Male volunteers, all heterosexual, 25–42 years old, in good health and with regular appearance.

Method
Field experiment; independent measures design.

Procedure
Each participant was asked to use his regular aftershave lotion after every shave for the duration of the study. Participants were also given a behavioural calendar that they had to fill out on a daily basis, indicating the incidence of the following six behaviours on that day:
- petting, affection and/or kissing
- sleeping next to a romantic partner
- sexual intercourse
- informal dates
- formal dates
- masturbation.

There was a baseline period of two weeks. After the baseline, a technician added either ethanol or a synthesized pheromone with ethanol to their aftershave lotion (depending on the condition). Ethanol was used as a masking agent to compensate for the possible smell of the pheromone.

This was followed by six more weeks of using the aftershave regularly and filling out the behavioural calendar.

Results
Compared to the control group, a larger number of participants in the pheromone group showed an increase over the baseline in the first four behaviours (petting, sleeping next to a partner, sexual intercourse and informal dates). Differences were not observed in the last two behaviours (formal dates and masturbation).

Conclusion
Researchers took this result as evidence that the synthetic human pheromone applied to the aftershave lotion increased sexual attractiveness of men to women.

An alternative explanation would be to say that it was the men's own libido that increased (so that they initiated contact with women more often). However, the fact that there was no change in formal dates and masturbation contradicts this explanation.

On the other hand, spontaneous sexual encounters were affected, indicating that the contact might have been initiated by women.

CRITICISM OF HUMAN PHEROMONE RESEARCH

Essential understanding
✪ *Research in the area of human pheromones has produced contradictory findings. Much of this research is flawed by the fact that authors are commercially interested in the results. There are also a number of methodological limitations compromising the quality of a typical study.*

Research is inconclusive
It must be admitted that research is inconclusive and the existence of human pheromones is not a scientifically established fact.

Contradictory findings
First of all, for every laboratory experiment that supports the existence of human pheromones, we can probably find a study that doesn't—this is the case with Lundstrom and Olsson (2005) versus Hare *et al* (2017).

Commercial interest
Secondly, field experiments in this area are rarely conducted due to the effort and funding that is required. When they are conducted, it is done by companies who are financially interested in the results. This was the case with Cutler, Friedman and McCoy (1998)—the first author of the study was the founder of a company that produced and marketed a synthetic human pheromone. That is why they do not reveal the formula of the chemical in their research paper. But this also means that an independent researcher cannot try and replicate the results of the study!

Inherent methodological limitations
Thirdly, there are major methodological limitations inherent in any research study in this field (Verhaeghe, Gheysen, Enzlin 2013).

Typical limitation	Explanation
Demand characteristics	It may be easy for participants to guess the true aim of the study because: – they are aware of the exclusion criteria, for example, women taking contraceptive pills are not allowed to participate in the study – the study includes surveys with questions about the participants' sexual orientation and sexual behaviours.
Ecological validity	Even in field experiments the concentration of pheromones used in the solution is much higher than that found naturally in human sweat. Some participants can even identify the unusual smell in the substance they are exposed to. If they use an aftershave lotion that smells unusual, this in itself can change their behaviour, making it less natural.
Internal validity	We are exposed to a large variety of smells in our daily lives, and these act as confounding variables. Effort is made to keep participants "odourless" for the duration of the experiment, but this is practically impossible to achieve.

Table 1.4

1.3 Genetics and behaviour

1.3.1 Genes and behaviour, genetic similarities

DEFINITIONS

- **DNA methylation—**the process by which certain chemicals (methyl groups) are added to the DNA molecule, affecting gene transcription
- **Epigenetic changes—**deviations of the phenotype from the genotype occurring as a result of changes in gene expression
- **Gene—**a part of DNA responsible for a specific trait or behaviour
- **Gene expression—**the process of synthesizing organic molecules based on the DNA blueprint; the manifestation of the genotype in phenotypical traits
- **Gene transcription—**part of gene expression; replicating the DNA sequence in a freshly synthesized RNA molecule
- **Gene translation—**part of gene expression; decoding the RNA molecule into a sequence of amino acids in a protein
- **Genotype—**the set of traits as it is coded in an individual's DNA
- **Phenotype—**a set of traits that actually manifest in an individual's body, appearance or behaviour

ESSENTIAL UNDERSTANDING

Debate and methods

The nature-nurture debate in its classic form asks whether it is biological or environmental factors that primarily affect behaviour. In the modern version of the question, the focus is on quantifying the relative contributions of the two factors and studying their dynamic interaction with each other. See **"The nature-nurture debate"**.

A variety of methods can be used to investigate genetic influences on behaviour. Some of these methods (twin studies, adoption studies and family studies) are based on the principle of genetic similarity. Other methods (molecular genetics) can be used to establish the role of specific genes in specific behaviours. See **"Methods of research"**.

The Falconer model

One of the ways to estimate heritability of a trait from results of a twin study is the Falconer model. This model assumes that the phenotypical variation of a trait is explained by the contribution of three independent factors: genetic inheritance, shared environment and individual environment. See **"The Falconer model"**.

Interaction of genes and environment

The Falconer model, however, does not take into account the possibility that these factors may themselves influence each other. For example, genetic factors can influence environmental factors by causing a growing individual to choose those bits ("niches") of the environment that are more in line with their genetic predisposition. See **"The influence of genetics on environment: niche-picking"**.

Conversely, environmental factors can influence gene expression—this is known as epigenetic changes. See **"The influence of environment on genetics: epigenetics"**.

Twin studies: example

Bouchard and McGue (1981) conducted a meta-analysis of 111 twin studies looking at heritability of intelligence. Applying the Falconer model to their data shows that 54% of variation in intelligence is due to genetic inheritance. While this is a large estimate, it also means that genetic inheritance is not the only factor influencing intelligence. See **Bouchard and McGue (1981)**.

Adoption studies: example

Scarr and Weinberg (1983) obtained two seemingly controversial findings.

- There is a considerable increase in IQ points when children with a poor socio-economic status are adopted by wealthier and more educated families.
- The IQ of adopted children correlates more strongly with the IQ of their biological, but not adoptive, parents.

This controversy is resolved by the idea of additive influence of genetic and environmental factors. See **Scarr and Weinberg (1983)**.

Studies employing methods of molecular genetics: examples

An example of a research study that used the methods of molecular genetics is **Caspi *et al* (2003)**. It was demonstrated that people with one or two short alleles of the 5-HTT gene are more vulnerable to stress and as a result more prone to depression. See **Caspi *et al* (2003)**.

Epigenetic studies also use modern technology to establish molecular mechanisms in the regulation of gene expression. **Weaver *et al* (2004)** explored how environmental factors (nurturing behaviour of rat mothers) can influence behaviour (stress reactivity) through the regulation of gene expression (methylation of certain gene sequences) without changing the gene itself. They found that less nurturing from the rat mother results in higher methylation of the glucocorticoid receptor gene, which in turn leads to fewer glucocorticoid receptors in the brain and higher vulnerability to stress. They were also able to reverse this effect with a drug. See **Weaver *et al* (2004)**.

EXAM TIP

There are two overlapping topics: "Genes and behaviour" and "Genetic similarities". It is important to understand which arguments and research studies are relevant to each topic.

This is best explained with reference to research methods. The four main methods used to study the influence of genetic versus environmental factors on behaviour are:

1. twin studies
2. adoption studies
3. family studies
4. molecular genetics (and epigenetics).

The first three methods are based on the principle of genetic similarity. Arguments and research studies based on these methods are relevant for the topic "Genetic similarities".

Methods of molecular genetics are used to establish specific genes responsible for a particular behaviour.

There are two possible ways in which questions on the topic "Genes and behaviour" may be asked.

1. If the question implies the influence of specific genes on behaviour, you should use arguments and research studies based on the methods of molecular genetics (and epigenetics).
2. If the question implies the influence of genetics in general, you can use any arguments and studies including those based on the principle of genetic similarities.

THE NATURE-NURTURE DEBATE

Essential understanding

✪ *The nature-nurture debate in its classic form asks if it is primarily biological or environmental factors that influence behaviour. Modern reformulation of the debate is concerned with quantifying the relative contributions of both factors and investigating their dynamic interaction with each other.*

The nature-nurture debate is one of the longest debates in psychology and philosophy. In its original form the question was whether human behaviour is primarily determined by biological factors (nature) or environmental influences (nurture).

This original form is outdated. There is little doubt that human behaviour is determined by both these factors to some extent. But once we acknowledge that, there are follow-up questions that need to be investigated.

- How can we quantify the relative contributions of nature and nurture to behaviour?
- Are nature and nurture really independent factors or is there some sort of interaction between nature and nurture themselves? For example, can biological factors influence the environment? Can environmental factors influence genetics?

An attempt to answer these questions would require sophisticated research methods.

METHODS OF RESEARCH

Essential understanding

✪ *Research into the role of genetics in human behaviour is conducted using methods like twin studies, adoption studies, family studies and molecular genetics. The first three are based on the principle of genetic similarity between various groups of individuals. The last one is aimed at identifying specific genes responsible for specific behaviours.*

Method	Explanation
Twin studies	Twin studies are based on comparing the similarity between monozygotic (MZ) twins to the similarity between dizygotic (DZ) twins for a particular trait or behaviour. MZ twins share 100% of their genotype and DZ twins share 50% on average. If a behaviour is genetically inherited, one might expect that MZ twins will be more similar to each other in terms of this behaviour than DZ twins.
Adoption studies	Adoption studies compare behavioural similarities in such groups of people as: – adopted children and their adoptive parents – adopted children and their biological parents – adopted children and their biological siblings.
Family studies	Family studies are based on collecting data about families on a broader scale, spanning several generations. The level of genetic relatedness is then compared to the observed similarities in a certain trait or behaviour. For example, assuming heritability of a trait, we might expect children to be more similar to their parents than to grandparents, more similar to siblings than cousins, equally similar to grandparents and aunts, and so on.
Molecular genetics	These methods use modern genetic mapping technology to investigate how behaviour is influenced by specific genes. Genetic mapping can reveal particular alleles of every gene in a given individual, and behaviour is then compared across groups of individuals who have different variants (alleles) of the same gene. Methods of molecular genetics are also used in epigenetics, the study of gene expression.

Table 1.5 Methods commonly used to study the effect of genotype on behaviour

THEORY

THE FALCONER MODEL

Essential understanding

✪ *The Falconer model is a way to estimate heritability of a trait from the observed similarities between MZ twins and DZ twins (rMZ and rDZ).*

The Falconer model is used with twin research data to quantify the relative contribution of heredity to a trait or behaviour. It makes the following assumption:

A + C + E = 1

(100% of observed variation in phenotype is explained by contributions from heredity A, shared environment C and individual environment E)

As applied to twins, shared environment is the part of the environment that two twins have in common, and individual environment refers to those bits of the environment that are unique to each twin.

To estimate A (heritability) in this model, you also need to take into consideration that:

rMZ = A + C

(there are two sources of similarity between monozygotic twins: 100% of shared genotype and the common environment)

rDZ = 1/2A + C

(the sources of similarity between dizygotic twins are the same, except that they only share 50% of their genotype, so the contribution from A is half as much)

Both rMZ and rDZ are measured directly in research. Plugging these values into the formulas above, it is easy to estimate A:

A = 2(rMZ – rDZ)

THE INFLUENCE OF GENETICS ON ENVIRONMENT: NICHE-PICKING

Essential understanding

✪ *Niche-picking is one of the ways in which genetic and environmental factors can dynamically interact. In niche-picking, genetic predisposition causes the individual to select certain aspects of the environment.*

Niche-picking is an example of how genetic factors can influence the environment. It is the phenomenon in which genetic predisposition causes individuals to select certain environments (or "niches" in the environment) which in turn influence their behaviour.

For example, a child who is genetically predisposed to depression may intentionally seek out environments where it is hard to succeed. This reinforces the child's low self-esteem and in turn contributes to depression. On the surface (for example, based on results of a twin study and the Falconer model) it may look like the main factor of depression is the demanding environment, but the environment itself was caused by genetics in the first place.

THE INFLUENCE OF ENVIRONMENT ON GENETICS: EPIGENETICS

Essential understanding

✪ *Environmental factors can play a role in the regulation of gene expression. Genotype as such is not changed, but the processes of synthesizing proteins based on the DNA may be affected.*

Gene expression is the biological process of manifesting the genotype as the phenotype. The DNA contains instructions for the synthesis of proteins, but constructing the protein based on these instructions is itself not simple. It includes two steps: transcription and translation. In **transcription**, the DNA sequence gets replicated in a freshly synthesized RNA molecule. In **translation**, this RNA molecule is decoded into a sequence of amino acids in a protein. Once the protein is synthesized, it is transported to its destination in the body.

A wide range of factors can play a role in regulating gene expression at any stage, from transcription to transportation. Some genes may be suppressed completely.

In the process known as **methylation**, certain chemicals (methyl groups) are added to the DNA molecule which represses gene transcription.

Methylation may be caused by environmental factors. This is how nurture can affect nature (not the genotype itself, but the expression of it).

Regulation of gene expression results in deviations of the phenotype from the genetic code. These deviations are known as **epigenetic changes**, and the area of research that investigates them is known as epigenetics.

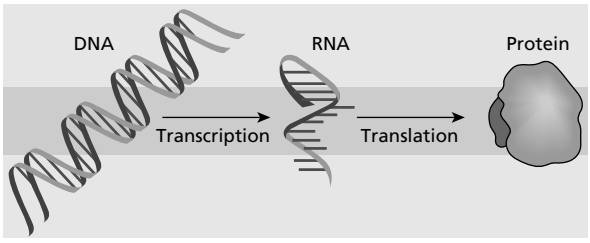

Figure 1.15 Gene expression

RESEARCH Bouchard and McGue (1981)—twin studies on heritability of intelligence

Essential understanding

✪ *Correlations of IQ scores tend to be higher for MZ twins than for DZ twins, which shows that intelligence is inherited to a considerable extent.*

Aim

To estimate heritability of IQ.

Method

Meta-analysis.

Participants

The meta-analysis included 111 twin studies that looked into heritability of intelligence. Participants in these studies included MZ and DZ twins (reared together and apart), siblings (reared together and apart), parents and their offspring.

Procedure

Researchers selected the studies based on a number of criteria, cleaned the data and calculated median correlations between IQ scores of individuals of interest (for example, MZ and DZ twins).

Results

There were numerous results obtained in the study, but we will only focus on a subset.

IQ correlation between:	% of shared genes	Median IQ correlation
MZ twins reared together	100	0.85
MZ twins reared apart	100	0.67
DZ twins reared together	50	0.58
Siblings reared together	50	0.45

Table 1.6

One way to process this data is to estimate heritability coefficients from the Falconer model. If you use the values of rMZ and rDZ (reared together) and plug them into the formula, you will obtain the heritability coefficient of 54%.

Conclusion

The study demonstrates that intelligence is inherited to a considerable extent (54% according to the Falconer estimate).

At the same time, it is not completely inherited. Even for MZ twins reared together, the correlation between their IQ scores is not perfect, which shows that the environment plays a certain role in the development of IQ.

RESEARCH Scarr and Weinberg (1983)—the Transracial Adoption Study

Essential understanding

✪ *This study shows a somewhat contradictory pattern of results—adopted children demonstrate a considerable improvement of IQ scores, but the correlation of their IQ is higher with the biological parents, not with the adoptive parents. This controversy is resolved in the idea of additive influence of genetic and environmental factors.*

Aim

To investigate environmental malleability of intelligence.

Participants

This study looked at 101 adoptive families who had both biological and adopted children. Some of the adopted children were black and some white. Some children were adopted in the first 12 months of life and some were adopted later. The study took place in Minnesota.

It needs to be understood that back at the time when the study was conducted, in Minnesota being black meant, on average, coming from a poorer socio-economic status background and being less educated.

Method

Adoption study.

Procedure

All children were assessed on IQ and school achievement tests. Correlations were calculated between the IQ of children and their parents (both adoptive and biological).

Results

The table shows the results of comparing IQ in various subgroups.

No	Group	Average IQ
1	Black children reared in their own homes	90
2	Adopted black children	106
3	Black children adopted in the first 12 months	110
4	Adopted white children	111
5	Natural children of the adoptive parents	119
6	Adoptive parents	120

Table 1.7

As can be seen from the table, black children placed in white families saw a substantial increase in their IQ. If they were adopted in the first year of life, they achieved the same level as adopted white children (although they had experienced a year of deprivation in the orphanage).

The table below shows the results of correlational research.

Correlation between	Value
Adopted children and their adoptive parents	0.29
Adopted children and their biological parents	0.43

Table 1.8

Conclusion

Results of the study may seem somewhat contradictory at first. On the one hand, there was a considerable

improvement in the IQ of adopted children. On the other hand, the correlation was higher with the IQ of biological parents, not adoptive parents.

These results demonstrate the idea of **additive influence** of genetics and environment in the development of IQ. The additive influence suggests that IQ can be influenced by environmental factors, but the extent to which an individual will be responsive to these favourable influences depends on genetic factors.

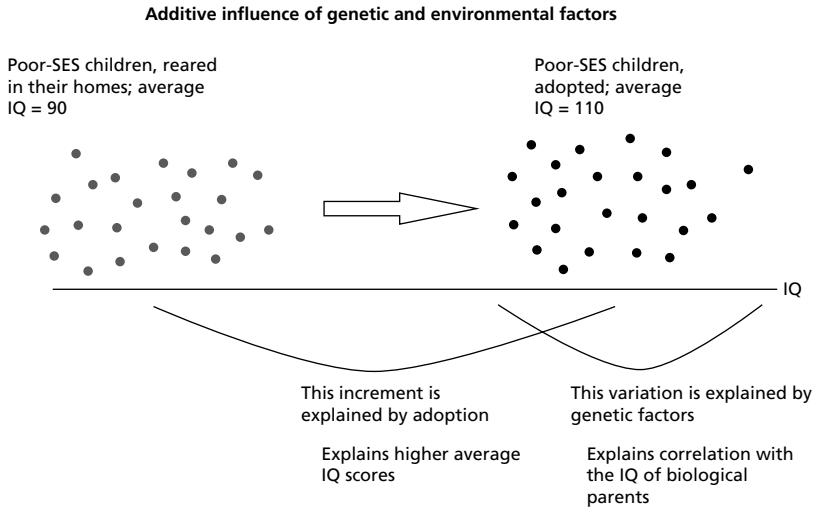

Figure 1.16 Additive influence of genetic and environmental factors

RESEARCH **Caspi *et al* (2003)—the 5-HTT gene and its role in depression**

Essential understanding

✪ *Methods used in molecular genetics help identify specific genes responsible for specific behaviours. One such example is the 5-HTT gene which is responsible for modulating the reaction to stressful life events. Individuals with short alleles of this gene reacted to stressful life events with more depressive symptoms.*

Aim

To investigate the role of the 5-HTT gene in developing depression in response to stressful life events.

Participants

1,037 children from New Zealand.

Method

A longitudinal study. Genetic mapping was used to divide participants into three groups:

- both short alleles of 5-HTT (s/s)
- one short allele and one long allele (s/l)
- both long alleles (l/l).

Procedure

Participants were assessed longitudinally between ages 3 and 26. Two measures were used: a "life history calendar" to assess stressful life events and an interview to assess symptoms of depression.

Results

Participants who had one or two short alleles of 5-HTT (s/l and especially s/s) reacted to stressful life events with more depressive symptoms. For example, participants who had a major stressful life event at age 21 tended to develop depression by age 26, but only if they carried a short allele of 5-HTT.

Conclusion

It was concluded that the 5-HTT gene is responsible for modulating an individual's vulnerability to stress.

RESEARCH **Weaver *et al* (2004)—the epigenetics of vulnerability to stress in rats**

Essential understanding

✪ *The less nurturing young rats receive from their mothers, the more transcription of the glucocorticoid receptor gene is inhibited. This results in fewer glucocorticoid receptors in the brain. Psychologically this means being more vulnerable to stress.*

Aim

To investigate the epigenetic mechanism in the influence of nurturing on vulnerability to stress.

Background

There exist stable, naturally occurring individual differences in nurturing behaviours of mother rats in the first week of lactation, for example licking and grooming (LG) and arched-back nursing (ABN).

Figure 1.17 Arched-back nursing

Participants

Laboratory-bred rats.

Method

A combination of methods:

- comparison of pre-existing groups (quasi-experiment)
- a rat adoption study
- an experiment, independent measures design

Measuring variables:

- genetic mapping technology, used to determine patterns of methylation of the gene sequence
- to measure response to stress, rats were placed in a Plexiglass restrainer for 20 minutes. Blood samples were taken before and after this procedure. Corticosterone (stress hormone) was measured in the blood.

Procedure and results

Method	Procedure/trial	Results	Notes
Comparison of pre-existing groups	Hippocampal tissue was obtained from adult offspring of high-LG-ABN and low-LG-ABN mothers. Mapping was carried out to investigate methylation of specific genes, most notably, the glucocorticoid receptor (GR) gene.	Significantly higher levels of methylation were registered in the offspring of low-LG-ABN mothers. These rats also showed more acute responses to stress.	**Glucocorticoids** (**gluco**se + **cor**tex + ste**roid**) are a class of steroid hormones. They regulate a variety of functions, including the organism's response to stress. Glucocorticoids affect a cell by binding to **glucocorticoid receptors (GR)** in that cell. These receptors, just like anything else in the organism, are synthesized based on a genetic plan, **the GR gene**. **Corticosterone** is a steroid hormone produced in the adrenal glands. In many animals it is the main glucocorticoid involved in the regulation of stress responses. In humans, the same function is performed by **cortisol**.
Rat adoption study	Biological offspring of high-LG-ABN mothers were cross-fostered to low-LG-ABN dams, and vice versa.	Results showed that GR gene methylation depended purely on the behaviour of the nurturing (adoptive) mother. For example, rats of low-LG-ABN mothers cross-fostered to high-LG-ABN dams showed the same patterns of GR methylation as biological children of high-LG-ABN rats.	
Experiment	A group of rats was given treatment with TSA (trichostatin A), a drug that counteracts the process of methylation in the GR gene.	Excessive methylation of the GR gene in the offspring of low-LG-ABN mothers was reversed. Responses to acute stress became normal (same as in the high-LG-ABN group).	

Table 1.9

Conclusion

- Vulnerability to stress may be determined by epigenetic factors—methylation of a gene responsible for the production of stress hormone receptors.
- Such methylation may be the result of environmental factors (such as mother nurturing).
- Effects of methylation in the first week of life (in rats) may be sustained throughout life and keep affecting their behaviour in adulthood.
- Such effects are reversible. Using drug treatment to stop methylation results in reducing vulnerability to stress.

1.3.2 Evolutionary explanations for behaviour

DEFINITIONS

- **Adaptation—**the process of changing to better suit demands of the environment
- **Disgust—**one of the basic human emotions; a feeling of revulsion caused by something unpleasant
- **Evolution—**the process by which organisms change from generation to generation due to the transmission of heritable characteristics
- **Massive modularity—**the assumption that the mind has evolved to serve different survival-related functions and hence must consist of "modules", each responsible for one of these functions
- **Natural selection—**the key mechanism of evolution; differential survival of individuals based on the extent to which they are adapted to the environment
- **Post-hoc reasoning—**explaining something after it has already happened

ESSENTIAL UNDERSTANDING

Evolutionary psychology attempts to apply the modern theory of evolution to explaining the observed variations in human behaviour. See **"The theory of evolution"**.

It has been applied to a wide range of behaviours, but we will focus on one example to illustrate the typical reasoning behind evolutionary explanations in psychology: the emotion of disgust.

The study of Curtis, Aunger and Rabie (2004) is an example of how evolutionary explanations in psychology are put to the test. Usually a phenomenon universal for all humans is selected (in this case the basic emotion of disgust). The evolutionary explanation for this phenomenon serves as a model upon which several predictions are made (if A is true, then B, C, D, E and F must also be true). The predictions are tested in an empirical study and if all observations fit the model well, the model is accepted. In this particular study, researchers demonstrated that several predictions about participants' ratings of disgust in response to disease-salient stimuli were in line with the evolutionary explanation: disgust is a response to disease-salient stimuli that allows the organism to avoid disease. See **Curtis, Aunger and Rabie (2004)**.

Although evolutionary psychology has a very high explanatory power and provides neat explanations for a wide range of phenomena, there are inherent and often unavoidable limitations that must be kept in mind: the assumption of mass modularity, lack of knowledge about ancestral environments, lack of testability and the existence of cross-cultural differences. See **"Criticism of evolutionary explanations in psychology"**.

THEORY

THE THEORY OF EVOLUTION

Essential understanding

✪ *The theory of evolution is based on the ideas of differential fitness, survival of the fittest and natural selection. Evolutionary explanations have been applied to a wide range of behaviours.*

The theory of evolution was first formulated by Charles Darwin in 1859 and was later expanded, accumulating the modern discoveries in genetics. Today's theory of evolution is based on the following main principles.

- Organisms are driven by the need to survive and reproduce.
- Organisms having different traits are adapted to their environment to varying degrees (differential fitness).
- Better-adapted organisms have higher chances of surviving and producing offspring (survival of the fittest).
- Less-adapted organisms produce less offspring, so their genes gradually disappear from the population. Genes of better-adapted organisms survive and are passed on to further generations (natural selection).

The theory provides some powerful explanations for the observed variation of species in the natural world. By analogy, evolutionary psychology attempts to apply this theory to explain the observed variation in human behaviour. Evolutionary explanations have been suggested for a wide range of behaviours.

RESEARCH **Curtis, Aunger and Rabie (2004)—evolutionary explanation for disgust**

Essential understanding

✪ *Findings of the study suggest that the emotion of disgust evolved as protection from risk of disease.*

Aim

Hypothetically, if disgust really is a product of evolution, the following must be true.

- Disgust should be stronger in response to stimuli that are associated with disease.
- Disgust responses should be similar cross-culturally.
- Disgust should be more pronounced in females since they have to protect the immune system of their babies as well as their own.
- Disgust should become weaker as the individual becomes older (because reproductive potential declines).

The aim of the study was to test these predictions.

Participants
Volunteers who completed a survey online. The total sample was over 77,000 people from 165 countries.

Method
Correlational study.

Procedure
Data was gathered in a survey placed on the BBC Science website. First, participants were asked a series of demographic questions, such as age and country of origin. Then they were asked to rate 20 photographs for disgust on a scale from 1 to 5. These photographs were similar pairs of digitally manipulated stimuli—one of the photographs in the pair was disease-salient and the other one less salient.

Results
All four predictions formulated by the researchers found support.

- Ratings of disgust in response to disease-salient stimuli were higher than ratings of disgust towards similar stimuli that were digitally manipulated to be less disease-salient. For example, a plate of organic-looking fluid was rated as more disgusting than a plate of blue fluid that looked chemical.
- Results were consistent across cultures.
- Results were more pronounced in the sub-sample of females.
- Ratings of disgust in response to disease-salient stimuli declined with age.

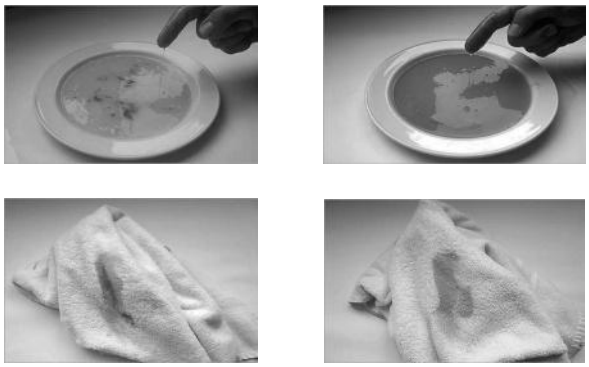

Figure 1.18 Examples of photographs used in the study by Curtis, Aunger and Rabie (2004)

Conclusion
Results of the study supported the evolutionary explanation: disgust is a biologically based response to disease-salient stimuli that reduces the risk of disease.

An evolutionary explanation is a model. The model is fit into observational data, and if it fits well, our confidence in the correctness of this model increases. Since in this study all four predictions formulated on the basis of the model were supported, one can say that the evolutionary explanation of disgust stood the test.

CRITICISM OF EVOLUTIONARY EXPLANATIONS IN PSYCHOLOGY

Essential understanding
✪ *Evolutionary explanations in psychology have a number of inherent limitations, most notably, the assumptions of mass modularity and linearity of development, lack of knowledge about ancestral environments, lack of testability and the existence of cross-cultural differences.*

Evolutionary psychology has a great explanatory power, but there are limitations inherent in all evolutionary explanations in psychology. These limitations are by and large unavoidable, so one needs to take them into account to avoid unjustified generalizations.

Limitation	Explanation
Massive modularity versus neuroplasticity	Massive modularity is the idea that the mind consists of certain "modules", each of which serves a particular survival-related function. For example, one such module may be responsible for feelings of disgust, another one may be responsible for quick detection of potential enemies, and so on. If we accept that the mind on the whole is a product of evolution, we must also accept the idea of massive modularity. The brain evolved and its different parts evolved to serve different survival-related functions. However, we also know that the brain demonstrates remarkable neuroplasticity, and this contradicts the idea of massive modularity.
Speculations about the environment	Adaptation is always adaptation to some environment, so in order to explain a change in behaviour using the theory of evolution, one must have knowledge about the environment in which such a change occurred. However, our knowledge of the environments in which our human ancestors existed is very limited. Much of this knowledge is speculative.
Testability	Evolutionary explanations are very difficult and often impossible to test. Critics claim that evolutionary psychology uses post-hoc reasoning—taking an already existing phenomenon and designing a believable explanation for it.
Cultural variation	Observed cultural variations weaken evolutionary explanations of behaviour. One can claim that different cultures evolved in different environments so such variation is perfectly plausible, but if cross-cultural differences are observed for basic phenomena that are thought to be universal (such as the basic emotion of disgust), then evolutionary explanations become questionable.

Table 1.10 Limitations of evolutionary explanations

1.4 The role of animal research in understanding human behaviour (HL only)

DEFINITIONS

– **Animal model—**a living organism whose behaviour resembles some aspects of human behaviour, which enables researchers to study this organism with the intention of generalizing results of the study to humans

ESSENTIAL UNDERSTANDING

Value of animal models

A fully identified animal model includes the species that is being used, the human behaviour that is being modelled and the type of experimental manipulation used in research. See **"Animal models: definition"**.

To what extent are animals biologically similar to humans? Structurally many parts of the human brain resemble the brain of other species. Some researchers believe that many parts of the human brain are equivalent to the brain of animal species. However, some have claimed that it is how the brain structure is connected to other parts of the brain that is of primary importance, and that although some parts of human and animal brain are similar structurally, their function may be very different. See **"To what extent are animals biologically similar to humans?"**

The major advantage of working with animal models is the possibility to carry out multiple experiments in highly controlled environments, often across generations. The major disadvantages are generalizability to humans, ecological validity and ethical issues. See **"Advantages and disadvantages of working with animal models"**.

Ethical considerations

Ethical considerations in animal research are regulated by professional bodies such as the APA. Most ethical considerations revolve around making justified research choices, carefully monitoring potential pain inflicted on the animals, and getting approval from independent review teams. See **"Ethical considerations in animal research"**.

Examples of research studies

Examples of research using animal models that have already been discussed in this unit are Lashley (1929), Merzenich *et al* (1984), Ferguson *et al* (2000), and Weaver *et al* (2004). These studies can be used to illustrate both the value of animal models in psychology and ethical considerations in animal research. These studies also cover all parts of the biological approach to behaviour (brain and behaviour, hormones and pheromones and behaviour, genetics and behaviour).

EXAM TIP

This HL extension includes three topics that can be applied to any of the three parts of the biological approach to behaviour. Combining these gives you nine potential areas from which exam questions may be asked.

Parts of biological approach to behaviour	a. Brain and behaviour	b. Hormones and pheromones and behaviour	c. Genetics and behaviour
1. The value of animal models in psychology	1a	1b	1c
2. Whether animal research can provide insight into human behaviour	2a	2b	2c
3. Ethical considerations in animal research	3a	3b	3c

Table 1.11

However, there is considerable overlap in these areas. Areas 1 and 2 are very similar because the value of animal models in psychology is determined mostly by the extent to which findings from research using such models can be applied to humans.

There is a lot of overlap also between a, b and c. Ethical considerations in animal research will be similar regardless of what we are investigating, brain structure, hormones or genetics. The same concerns the value of animal models in psychology. Specifics may differ, but the major arguments will be the same.

With this in mind, we will:

– consider common arguments related to the value of animal models in psychology (in general)
– consider the main ethical considerations in animal research (in general)
– discuss examples of animal research in psychology that will allow you to apply these general arguments to concrete research studies.

ANIMAL MODELS: DEFINITION

Essential understanding

✪ *A fully identified animal model includes the species that is being used, the human behaviour that is being modelled and the causal factor that is tested in research.*

An animal model is a concept that refers to using animal research to test a certain cause-effect hypothesis about a certain human behaviour. This term is often used somewhat loosely, for example, you can see mentions of "mouse models" to denote the general idea that mice can be used to model human behaviour. However, to fully identify an animal model, it is important to include the following information:

- what animal species is being used
- what behaviour is being modelled
- what causal factor is being investigated (or what hypothesis is being tested).

For example:

- a mouse stress model of depression (read: using mice to investigate the idea that exposure to stress increases the risk of developing depression in humans)
- a rhesus monkey separation model of cognitive delay (read: using rhesus monkeys to investigate if separation from attachment figures will cause delays in cognitive development, and generalizing these findings to humans).

TO WHAT EXTENT ARE ANIMALS BIOLOGICALLY SIMILAR TO HUMANS?

Essential understanding

✪ *It has been suggested that since some parts of our brain are very similar to the brain structures of animals, on some level our psychological functions should be equivalent. However, some researchers claim that the similarity can be deceitful, and the new additions have changed our psychological functions fundamentally. An example is the use of chunking in short-term memory. Although some separate brain structures in animals and humans may be similar, it is the way these structures are connected to the rest of the brain that makes a difference.*

Some theories have suggested that the human brain is a reflection of the evolution of the species and that genuinely "human" brain structures were added in the process of evolution on top of the more primitive structures that can be found in lower animals. This suggests that the human brain is very similar to that of animals.

However, evolution of the brain may have been more complex than simply building newer structures on top of the older ones.

Premack (2007) suggested that researchers should compare psychological functions as well as brain structure. He also claimed that we should focus on finding dissimilarities between animals and humans so that we better understand the limitations of generalizing from animal studies.

An example of comparing psychological functions in animals and humans (Premack 2007) is short-term memory in humans and chimpanzees. A chimpanzee has the same limit for the number of units it can remember without rehearsing (about seven units). However, unlike primates, humans are able to "chunk". You can train a chimpanzee to recognize letters such as B, M, W, X, B, O and X. However, although the capacity of short-term memory is the same, the sequence BMW XBOX will represent seven units of information for a chimpanzee and only two units for a human being. Arguably, chunking makes a qualitative difference to how memory works. Hence, short-term memory in humans and chimpanzees may be similar, but it is not equivalent.

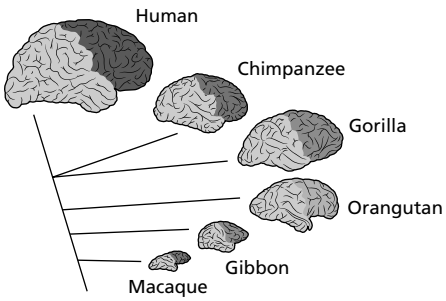

Figure 1.19 Human brain and animal brain

ADVANTAGES AND DISADVANTAGES OF WORKING WITH ANIMAL MODELS

Essential understanding

✪ *The major advantage of working with animal models is the possibility to carry out multiple experiments in highly controlled environments, often across generations. The major disadvantages are generalizability to humans, ecological validity and ethical issues.*

Some of the **advantages** of working with animal models include the following.

- In some ways humans and animals are biologically and genetically identical. This means that some aspects of animal behaviour may be generalizable to humans.
- Studies with animal models have produced useful results. For example, many drugs were first discovered in animal studies and tested on humans later.
- Some animals (such as mice) have a short lifespan, which allows researchers to see how behaviour changes from generation to generation. This is especially helpful in genetic research.

– In animal research it is possible to control confounding variables more strictly than in research with humans. For example, the "knockout" technique allows researchers to selectively switch off one of the genes in the DNA sequence.
– Animal subjects are easily accessible, easy to handle and manage.

Some of the **disadvantages** include the following.
– As discussed (Premack 2007), even if animals and humans are similar biologically, they can still be different psychologically.
– Successful trials from animal research still need to be replicated with humans to be sure that results are generalizable. As a matter of fact, in biomedical research (when developing new drugs) tests are often conducted in a hierarchy: first mice, then mammals, then great apes, then humans.
– Many studies that are successful in animals fail to achieve the same results with humans. The reasons are usually unclear. Such was the case with potential HIV treatments: 85 different vaccines worked well for primates, but none of them worked for humans (Bailey 2008).
– Animal studies tend to be strictly controlled laboratory experiments, which creates issues with ecological validity. There is a possibility that animals would behave differently in their natural habitat.
– There are ethical considerations related to experimentation with animals.

ETHICAL CONSIDERATIONS IN ANIMAL RESEARCH

Essential understanding

✪ *Ethical considerations in animal research are regulated by professional bodies such as the APA. Most ethical considerations revolve around making justified research choices, carefully monitoring potential pain inflicted on the animals, and getting approval from independent review teams.*

APA guidelines

The American Psychological Association (APA) has published guidelines on conducting research with animals that regulate every step of the research process. Some of the major guidelines are summarized below (American Psychological Association 2012).

Justified choices

– Any animal study should be clearly justified with a scientific purpose. It should either increase our knowledge or benefit humans or other animals.
– The chosen species must be the best choice for the research purpose.
– The minimum required number of animals must be used.

Inflicting pain

– It has to be assumed that whatever procedures cause pain in humans would cause pain in animals too.
– Researchers conducting the study must be familiar with the species-specific characteristics of normal behaviour so that they will be able to tell when the animal is stressed or unhealthy.
– Whenever possible, laboratory procedures must be designed in a way that minimizes animal discomfort.
– Whenever reasonable, researchers must first test the painful stimuli to be used with animals on themselves.
– If a research animal is observed to be in distress or chronic pain and this is not necessary for the purposes of the study, it should be euthanized.
– Animals reared in the laboratory must not be released into the wild.

Obtaining approval

– All animal research proposals must be submitted to the Ethics Committee prior to conducting the study.

BPS guidelines

The British Psychological Society (BPS) published a policy (British Psychological Society 2012) on the use of animals in psychology which is based on three principles (three Rs):
– replacement (animals should only be used when no alternative exists)
– reduction (the minimal necessary number of animals must be used)
– refinement (it must be ensured that experimental procedures cause minimal necessary distress in the animals).

EXAMPLES OF RESEARCH USING ANIMAL MODELS

Essential understanding

✪ *Examples of research using animal models that have already been discussed in this unit are Lashley (1929), Merzenich et al (1984), Weaver et al (2004) and Ferguson et al (2000). These studies can be used to illustrate both the value of animal models in psychology and ethical considerations in animal research. These studies also cover all parts of the biological approach to behaviour (brain and behaviour, hormones and pheromones and behaviour, genetics and behaviour).*

Examples from this unit

In this unit you have come across several research studies using animal models. These studies can be used to support all arguments in this topic—the value of animal models in psychology, whether animal research can provide insight into human behaviour, and ethical considerations in animal research.

Research study	Description
Lashley (1929)	Removing various portions of the cortex to investigate where the memory of the maze is localized. See **"1.1.1 Localization"**.
Merzenich *et al* (1984)	Investigating cortical representations of the hand in adult owl monkeys (amputation of fingers). See **"1.1.1 Localization"**.
Weaver *et al* (2004)	Investigating the epigenetic mechanism of how nurturing received by rats from their mothers affects the way their brain responds to stress later in life. See **"1.3.1 Genes and behaviour, genetic similarities"**.
Ferguson *et al* (2000)	Investigating the role of oxytocin in social memory by studying oxytocin gene knockout mice models. See **"1.2.1 The influence of hormones on behaviour"**.

Table 1.12

Coverage of topics

	Brain and behaviour	Hormones and pheromones and behaviour	Genetics and behaviour
Lashley (1929)	X		
Merzenich *et al* (1984)	X		
Weaver *et al* (2004)		X	X
Ferguson *et al* (2000)		X	X

Table 1.13

Insight into human behaviour and ethical considerations

	To what extent can the study provide an insight into human behaviour?	Ethical considerations
Lashley (1929)	Lashley's experiments with rats cannot be replicated with human participants for ethical reasons. However, the study was insightful because it suggested that some functions can be widely distributed in the brain. This idea can be used to explain findings from human studies (for example, Sperry and Gazzaniga).	Rats in the study were harmed because invasive surgery was performed on their brain. Such studies must ensure that this degree of suffering is absolutely necessary for the purposes of research, that potential benefits of research results justify the experimental procedure, that the minimum necessary number of animals is used, and that approval is obtained from the Ethics Committee.
Merzenich *et al* (1984)	Neuroplasticity in response to structural damage is observed in the human brain as well, but a direct experiment would not be possible for ethical reasons (that would require producing physical impairment in human subjects). So human research in this area is limited to case studies of people with injury. Cause-and-effect inferences cannot be made from case studies. Research with animal models helps test cause-effect hypotheses and in this sense provides further insight into human behaviour.	This research used a very invasive experimental manipulation which had a damaging and irreversible effect on the animals' lives (amputation of fingers). The technique used to measure the cortical response also involved inserting electrodes into the brain. Such research proposals must be carefully scrutinized by the Ethics Committee and only approved if potential gains outweigh the costs. Experimenters must make sure that animals are properly anaesthetized during the procedure and taken care of after the end of the study for the duration of their lives.
Weaver *et al* (2004)	This research is insightful because it gives birth to many interesting hypotheses about human behaviour. Potentially it is also very useful. It suggests that effects of bad parenting may be epigenetic. By analogy, one can suggest that effects of poverty on cognitive development, for example, may also be epigenetic. If this is so, potentially we can invent drugs that will reverse these effects (imagine an "anti-bad-mother pill"). This has led researchers to construct many ingenious research studies to test similar hypotheses with human subjects.	Animals in this study were laboratory-bred in a special way to obtain the necessary genotype. Epigenetic tests were invasive—they required obtaining a sample of cells from the brain. Stress tests where animals were placed in a narrow tube that restrained their movements were also harmful for the rats, as were the increased levels of stress hormones. Such studies must be carefully justified and approved by the Ethics Committee. If approval is obtained, researchers must be accountable for humane handling of the animal subjects.
Ferguson *et al* (2000)	As a knockout study, it provides a very direct test to the role of oxytocin in behaviour. In humans we can only temporarily increase the level of oxytocin, so research is limited to short-term effects. With animal models these effects can be studied over the lifespan of the animal.	Mice were specially bred in this study. They were also cross-fostered. In fact, female oxytocin gene knockout mice do not lactate, so they cannot foster offspring. Ethical considerations that apply in this study are similar to Weaver *et al* (2004).

Table 1.14