# PSYC10003 – Detailed Notes

## About these notes

These notes follow the PSYC10003 Mind, Brain and Behaviour 1 subject across its four topics: behavioural neuroscience (Weeks 1–4), sensation and perception (Weeks 5–8), learning and cognition (Weeks 9–12) and psychological research methods. Each section sets out the definitions, case studies, mechanisms and key findings for that week.


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**The neuron**

- The neuron is the basic information-processing and information-receiving unit of the nervous system. Neurons form complex networks that are not directly connected to one another: they are separated by tiny gaps called synapses, across which chemicals called neurotransmitters are passed.
- Neurons contain four basic structures:
    - **Cell body (soma):** contains the nucleus and the internal organelles necessary for cell maintenance.
    - **Dendrites:** tree-like branches that allow neurons to communicate with one another by receiving information from other neurons.
    - **Axon:** a long, slender fibre that carries signals away from the cell body. The signal carried by an axon is called an action potential.
    - **Terminal buttons:** small knobs at the ends of the many branches of axons that play a critical role in transmitting information from one neuron to another by secreting a neurotransmitter. This chemical passes across the synaptic gap and can either excite or inhibit subsequent neurons.
- Organelles inside the cell body carry out cell maintenance and functioning:
    - **Cytoplasm:** the jelly-like substance inside the cell. It contains the mitochondria, which use glucose (and oxygen) to produce energy.
    - **Nucleus:** contains the cell's chromosomes, which consist of deoxyribonucleic acid (DNA). Genes on the chromosomes provide the recipes for creating proteins.

**Glial cells (glia)**

- Neurons make up about 50% of the cells of the CNS. The other half is made up of various other cells, collectively known as glial cells (glia). Glia play an important role in providing physical support for neurons and supplying them with oxygen and nutrients.

| Glial cell | Function |
|---|---|
| Astrocytes | Provide physical support for neurons, clean up waste and provide nutrients to neurons |
| Oligodendrocytes | Provide physical support to neurons and the insulating myelin sheath that surrounds the axon in the CNS, which stops unwanted cross-talk between neighbouring axons |
| Microglia | Small glial cells that act as the brain's immune system by attacking invading micro-organisms; also largely responsible for inflammation after brain damage |
| Schwann cells | Perform the same function as oligodendrocytes but in the peripheral nervous system (PNS): they create a myelin sheath around the axons of neurons in the PNS |

**Electrical signalling within the neuron**

- Neurons transmit signals along the axon by movements of electrically charged particles called ions across the axon membrane. This process is electrical.
- The inside of the neuron is negatively charged relative to the outside (the resting membrane potential, about −70 mV). Adding a positive electrical current through an electrode (a conductor of electricity) causes depolarisation: the loss of the difference in charge between the inside and outside of the plasma membrane of a nerve cell, so the membrane potential moves towards zero.
- Action potentials occur naturally and are determined by the balance of positively and negatively charged ions inside and outside the neuron. Two forces act on the ions:
    - **Diffusion:** the movement of particles from regions of high concentration to regions of low concentration. For example, when sugar is added to water, the molecules dissolve and distribute themselves evenly.
    - **Electrostatic pressure:** the force on two similarly charged ions to repel each other and the force on two oppositely charged ions to attract each other. There are two types of ions:
        - **Anion:** a particle that has gained an electron and is therefore negatively charged.
        - **Cation:** a particle that has lost an electron and is therefore positively charged.
- Four ions are crucial to the resting membrane potential: two cations and two anions.

| Ion | Charge | Where it is more concentrated |
|---|---|---|
| Sodium (Na+) | Cation | Outside the neuron |
| Potassium (K+) | Cation | Inside the neuron |
| Chloride (Cl−) | Anion | Outside the neuron |
| Organic anions (proteins, A−) | Anion | Inside the neuron (cannot cross the membrane) |

- The inside and outside of a neuron are like two containers separated by gates that are usually closed. When the gates between the inside and outside of the neuron open, ions move because of diffusion and electrostatic pressure (for example Na+ is driven into the cell, because it is both more concentrated outside and attracted to the negative interior). These changes in charge can be measured with electrodes and a voltmeter.
- **Sodium–potassium pump:** a force that actively pushes excess sodium (Na+) ions out of the cell (and brings potassium ions in). Sodium–potassium transporters are present in neurons and glia (and most other cells of the body) and consume about 40% of a neuron's metabolic resources.
- **The all-or-none law:** neurons have a threshold for excitation at which an action potential is triggered, so the action potential either occurs completely or does not occur at all.

# Week 2: The Synapse and the Structure and Function of the Human Nervous System

## 2.1 The synapse

### Myasthenia gravis

- An autoimmune disorder causing abnormal weakness of certain muscles. The name means "grave muscle weakness", as first described by Thomas Willis in 1672.
- Symptoms: extreme fatigability, fluctuating muscle weakness, problems chewing and talking, and respiratory weakness.
- Action potentials in nerves remain normal, because the condition arises from a problem with the synapses on muscles (the neuromuscular junction, where the immune system attacks the receptors that respond to the neurotransmitter acetylcholine).

### Release of a neurotransmitter

1. Vesicles (small membrane-bound packages) contain neurotransmitter molecules.
2. An action potential in the presynaptic cell triggers the vesicles to move toward the cell membrane, as guided by proteins.
3. The guiding proteins pull the vesicle and the presynaptic membrane together.
4. An influx of calcium ions into the presynaptic terminal button causes the two membranes to fuse.
5. Neurotransmitter molecules are released into the synaptic cleft (the gap between the two neurons).

### Receptors and postsynaptic potentials

- **Ionotropic receptors:** receptor proteins that have their own binding sites. When a neurotransmitter molecule attaches to a binding site, an ion channel opens (like a key in a lock). (Metabotropic receptors, in contrast, act more slowly through chemical messengers inside the cell.)
- **Postsynaptic potentials:** changes in the membrane potential of the postsynaptic terminal of a chemical synapse. They can be either excitatory or inhibitory.
- **Excitatory postsynaptic potentials (EPSPs):** depolarise the postsynaptic cell membrane and increase the likelihood that an action potential will be triggered in the postsynaptic neuron.
- **Inhibitory postsynaptic potentials (IPSPs):** hyperpolarise the postsynaptic cell membrane (make the inside more negative) and decrease the likelihood that an action potential will be triggered in the postsynaptic neuron.
- **Neural integration:** the combined effect of EPSPs and IPSPs. The postsynaptic neuron fires only if the summed input brings the membrane to threshold.

## 2.3 Structure and function of the human nervous system 2

### Lobes of the cerebral cortex

| Lobe | Position | Function |
|---|---|---|
| Frontal | Rostral (front) of the cortex | Responsible for the unique human ability to plan, reason and reflect on one's own behaviours; especially large in humans |
| Parietal | Caudal to the frontal lobe and dorsal to the temporal lobe | Left hemisphere: aspects of language comprehension and mental arithmetic. Right hemisphere: representing the locations of important objects in space |
| Temporal | Ventral to the frontal and parietal lobes | Left hemisphere: understanding spoken and written language. Right hemisphere: may be particularly involved in recognising complex objects and faces |
| Occipital | Caudal to the parietal and temporal lobes | Processes various aspects of visual information, such as motion, colour and shape |

- **Corpus callosum:** a large bundle of axons connecting cortical areas of the two cerebral hemispheres, so that perception, memory and thinking processes are unified.

### Subcortical structures

- **Limbic system:** a set of structures hidden inside the medial part of each hemisphere, tasked with functions related to motivation and emotion. The most important parts are:
    - **Hippocampus** ("seahorse"): critical for learning and the formation of new memories.
    - **Amygdala** ("almond"): involved in the experiencing of emotions such as fear.
- **Basal ganglia** (ganglion means "swelling"): a collection of nuclei located deep within each hemisphere. They contain cell bodies of neurons and are classified as grey matter even though they are not part of the cerebral cortex. The principal nuclei are:
    - Caudate nucleus: "nucleus with a tail".
    - Putamen: "shell".
    - Globus pallidus: "pale globe".
- These nuclei are responsible for controlling movement, especially automatic movement such as walking.
- **Diencephalon:** a major division of the forebrain surrounding the third ventricle in the middle of the brain. It consists of two major parts:
    - **Thalamus** ("inner chamber"): a major relay station for sensory information conveyed to the cerebral cortex; forms the dorsal part of the diencephalon and is divided into several nuclei.
    - **Hypothalamus** ("under the thalamus"): located just beneath the thalamus, it controls the autonomic nervous system and the endocrine system. It also regulates behaviours necessary for survival, such as fighting, feeding, fleeing and mating.

| Disorder | Cause | Effect |
|---|---|---|
| Hemianopia | Damage to area V1 | Loss of vision for one side (left or right) of the visual field; patients are normally aware of their visual loss |
| Hemiachromatopsia | Damage to area V4 | Impaired colour perception for one side; patients continue to see forms and movement, but one half of the world is seen in black and white |
| Achromatopsia | Damage to V4 in both hemispheres | Vision without colour |
| Akinetopsia | Damage to area V5 | Exceedingly rare loss of visual motion perception; patients can still see colour and form |
| Visual object agnosia | Damage to the visual association areas of the temporal lobe | Selective loss of the ability to recognise familiar objects through vision; patients can recognise objects through other senses such as hearing and touch but may fail to recognise simple everyday objects by sight alone |
| Prosopagnosia | Damage to the fusiform gyrus, the region of the inferior part of the temporal lobe crucial for face recognition | Loss of facial recognition |

**Commentary 3: is the binding problem really a problem?**

- The brain is depicted as a modular structure with specific areas tasked with specific functions when viewed from the outside.
- Areas in the visual cortex contain neurones sensitive to particular aspects of the input:
    - Areas V2 and V3: sensitive to form and depth.
    - Area V4: sensitive to colour.
    - Area V5 (or area MT): sensitive to motion.
- Area V5 has neurones that are very sensitive to motion of the input and can integrate motion across their receptive fields in certain situations. However, they are less sensitive to colour, depth and form.
- **Binding problem of vision:** features such as colour and shape are initially encoded together but analysed by different areas of the brain. If there are multiple maps of the visual world, how and where in the brain are they all put together to form a coherent single representation that matches human experience?

**Commentary 4: constructing the world**

- **Primary visual cortex (area V1):** represents everything perceived in the world, as visual input enters at this point. It accounts for the information in a general sense, in that the output of individual neurones at this level is not specialised.
- The visual system deals with the need for more specialised, specific data to perform complex tasks by segregating important aspects of the data contained in area V1 and transmitting particular information to other areas (for example, colour information is transmitted to neurones in area V4).
- The system can then process particular properties of the input simultaneously, by the bundling of tasks given to different visual areas.

**Commentary 5: motion detection**

- Motion is one fundamental component of the visual input, along with colour, form and depth, and is associated with movement.
- Much interest and research have gone into how motion is identified in an image over the last 30 years. Nevertheless, uncertainty remains regarding the detection of motion in the visual system. Some propose that the initial signal specific to the motion subsystem is tied to the direction of motion of an edge, coded by a change in luminance or even colour.
- **Simple motion vectors:** signals indicating the direction and speed of some aspect of an image on the retina, assumed to be a luminance-defined border that appears to provide the primary input to the human sense of motion.
- The vector provides the initial fragment of what eventually becomes the human sense of motion in the image. Once a motion vector has been characterised in space, it is compared with other motion vectors at different sizes and at nearby points in space and time.
- **Depth** is highly influenced by motion, both in terms of what is occluding what (suggesting that something is in front of something else) and in terms of **motion parallax**, the relative motion of objects at different depths as an individual moves their viewpoint.

## Topic 4: Psychological Research Methods

### Module 1: Introduction to psychological research methods

- Many things claim to treat experiences like depression and anxiety. However, psychologists rely on scientific evidence to determine whether a therapy works before offering it to clients. Such evidence comes from scientific research.
- Does this treatment for depression or anxiety work?
    - A study is designed to test the effect of the treatment on people's depression or anxiety level.
    - A sample of participants with depression or anxiety is recruited.
    - The treatment is given to participants.
    - The data are analysed to test the effectiveness of the treatment.
    - Conclusions are drawn and findings are reported.
- **The research process:** research question and hypothesis → define variables and measurement → study design → sampling → data collection → data analysis → develop conclusions and report findings → think critically and refine hypotheses.
- Psychology is an evidence-based discipline guided by research and critical thinking.

### Module 2: Constructs and operational definitions

- Psychological research is challenging because it focuses on phenomena that are not directly observable.
- **Constructs:** intangible, abstract attributes that are theorised to underlie observable behaviour. They cannot be directly observed or directly measured.
- **Operational definition:** the process of defining and measuring an unobservable construct in an indirect manner.
- Example: happiness is an abstract attribute, so how can it be measured? Smiling behaviour is measurable because it is observable, yet it may not indicate happiness.
- Intelligence is another construct, as it is physically intangible. IQ is an operational definition, and therefore a way to measure intelligence.

### Module 3: Research questions and hypotheses

- The research process begins with a question. **Research questions** are broad ideas that usually ask about association, difference or causation. There are therefore three kinds of research question:
    - **Association:** "Is happiness related to sunshine?"
    - **Difference:** "Are arts students happier than science students?"
    - **Prediction (causation):** "Does happiness influence academic performance?"
- **Hypotheses:** logical, specific, testable, refutable and predictive statements about what will happen in a psychological research study. For example: "higher levels of reported happiness will be related to higher average daily duration of sunlight exposure".

## 11.2 Long-term memory and amnesia

### Divisions of long-term memory

- **Long-term memory (LTM):** a memory store that holds knowledge indefinitely. It has two major divisions:
    - **Declarative memory (explicit):** knowledge that can be consciously recalled (what, why, when, where, who), such as facts, events and locations. It depends on the hippocampus.
    - **Non-declarative memory (implicit):** knowledge that is recalled unconsciously (how), such as motor skills (for example riding a bike) and cognitive skills (for example reading). It does not depend on the hippocampus.

| Division | Type | Description | Example |
|---|---|---|---|
| Declarative (explicit) | Episodic memory | Conscious knowledge of temporally dated, spatially located and personally experienced events or episodes; memories involved with the "when" and "where"; contextualised memory; "mental time travel" | Remembering your last birthday |
| Declarative (explicit) | Semantic memory | Knowledge about words and concepts, their properties and interrelations; facts and general knowledge about the world; memories involved with the "what" and "why"; abstract knowledge | Knowing that Paris is the capital of France |
| Non-declarative (implicit) | Procedural memory | Learning motor and cognitive skills | Riding a bike |
| Non-declarative (implicit) | Priming | A change in the ability to identify a stimulus as the result of prior exposure to that stimulus or a related stimulus | Prior presentation of "nurse" facilitates identification of "doctor" |
| Non-declarative (implicit) | Associative learning | Classical conditioning and operant conditioning | A neutral stimulus becomes meaningful through association |
| Non-declarative (implicit) | Non-associative learning | Habituation and sensitisation | Screening out background noise |