The Divisions of the Nervous System

AQA specification for Topic 5: Biopsychology

- The divisions of the nervous system: central and peripheral (somatic and autonomic).

Introduction

There are close links between biology and psychology. Biology can influence our behaviour. For example, changes in our brain chemicals influence our moods and emotions (think of serotonin and dopamine) and can also influence our biology. For example, certain stressors in life (e.g. work, deadlines, social relationships) have been shown to influence our immune system. So, the term **biopsychology** is concerned with the ways in which biological factors influence our emotions, behaviours, and mental processes.

Nervous system

All humans are made up of cells. Neurons (nerves) are specialist cells that make up the nervous system. The nervous system is made of trillions of neurons (or nerve cells) whose purpose is to carry messages passed by neurotransmitters as part of electrical and chemical (electrochemical) processes. The nervous system is divided into two subsystems: the *central nervous system* (CNS) and *peripheral nervous system* (PNS). The CNS comprises the brain and spinal cord, which carry sensory information from the arms, legs and body to the brain. The two main roles of the CNS are: 1) To control our behaviour by processing and responding to information from the environment, and 2) To regulate and co-ordinate the working of different physiological processes (e.g. organs and cells) in the body. To do this, the brain receives information from the sensory receptors (e.g. eyes and skin) about the social environment and sends messages to the body's muscles and glands. These messages are sent through the spinal cord, a collection of nerve cells that are attached to the brain and run the length of the spinal column.

The central nervous system (CNS)

As mentioned above, the **brain** and the **spinal cord** make up the **central nervous system** (CNS). The nerves that spread out from the CNS make up the **peripheral nervous system**. The PNS is connected to all our body parts such as our internal organs, muscles and glands. The CNS does not have any direct communication with the outside world. It is the PNS that conveys the information about the outside world to and from the CNS. The spinal cord is vital for the processing and transferring of information, which takes place via neurons. The main job of the CNS is to process the information and regulate physiological processes, to ensure that life is maintained!

The brain

The brain is divided into four main areas:

- **Cerebrum:** the largest part, which is responsible for many functions such as speech production and processing visual images.
- **Cerebellum:** the part that controls motor skills and balance.
- **Diencephalon:** the part that contains the thalamus which acts as a relay station for nerve impulses coming from the senses, and the hypothalamus which is responsible for the regulation of body temperature among other things. The hypothalamus also triggers hormones to be released from the pituitary gland.
- **Brain stem:** the part that regulates functions essential for life such as heartbeat, swallowing and breathing.

The spinal cord:

- **Relays information** between the brain and the rest of the body.
- Is connected to different parts of the body by **spinal nerves** that connect to specific **muscles** and **glands**.
- Contains circuits of nerves that perform **simple reflexes** without the direct involvement of the brain, such as pulling your hand away from a hot plate.

◆ Peripheral nervous system (PNS)

- Nerves that come off from the central nervous system are called the **peripheral nervous system (PNS)**. The PNS can be further divided into two sections the **somatic nervous system** and the **autonomic nervous system**.

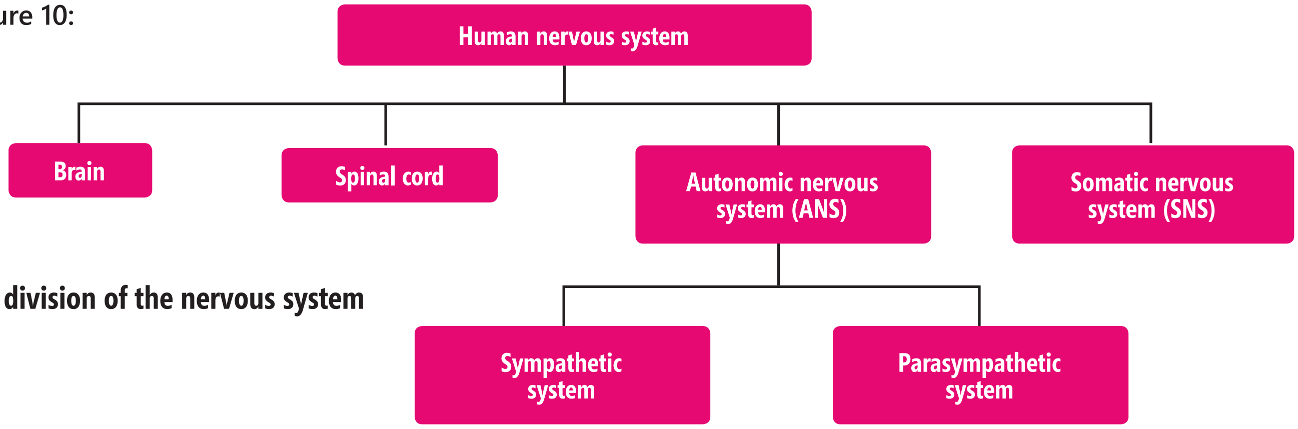
The somatic nervous system

- Somatic nervous system (SNS) is responsible for transmitting sensory information via the central nervous system (CNS) to other areas of the body. The SNS does this by carrying sensory information about the environment (e.g. from the eyes, sound, skin) using sensory neurons to the CNS (spinal cord and brain), which then sends the information from CNS to other areas of the body (e.g. skeletal muscles), using motor neurons. The SNS is also involved in reflex actions without the involvement of the central nervous system, which allows the reflex to occur very quickly. So, in a nutshell, the SNS:
  - is under our conscious control whereas the ANS (below) is involuntary (not under our control).
  - is made up of nerves coming from the **brain** and the **spinal cord**.
  - contains both **sensory** and **motor** neurons.
    - » **Sensory neurons** relay messages <u>*to*</u> the CNS (spinal cord + brain).
    - » **Motor neurons** relay messages <u>*from*</u> the CNS (spinal cord + brain).

The autonomic nervous system

- The role of the **autonomic nervous system (ANS)** is to regulate the involuntary actions of internal body organs, such as heartbeat, glands, digestion, breathing, and temperature, without us being consciously aware of these happening. It is called autonomic (automatic) because we have no control over it, it happens involuntarily. The ANS is necessary because things like heartbeat and digestion would not work so efficiently if we had to think about them. The ANS can be further divided into two parts, the *sympathetic* and *parasympathetic*. These work on the same organs but have opposite effects. One increases the activity, the other decreases the activity.
  - **The sympathetic nervous system (SNS)** is primarily involved in increasing body responses that respond to a perceived threat, danger or emergency. It produces physiological changes such as increased heart rate, breathing and blood pressure and also prepares the body for fight or flight.
  - **The parasympathetic nervous system (PNS)** is involved with energy conservation and slows down physiological activity (such as heart rate), decreases blood pressure, stimulates the digestive system, and stores energy for future use, when the threat has passed.

Figure 10:



The division of the nervous system

Sympathetic branch
- Increases heart rate
- Increases breathing rate
- Dilates pupils
- Inhibits digestion
- Inhibits saliva production
- Contracts rectum

Parasympathetic branch
- Decreases heart rate
- Decreases breathing rate
- Constricts pupils
- Stimulates digestion
- Stimulates saliva production
- Relaxes rectum

Practice exam questions

1. Complete the following sentence. **[1 mark]**

Circle one letter only.

Motor neurons carry information:

A. away from the brain.

B. both to and from the brain.

C. towards the brain.

D. within the brain.

2. Complete the following sentence. **[1 mark]**

Circle one letter only.

The somatic nervous system:

A. comprises of two sub-systems.

B. connects the central nervous system and the senses.

C. consists of the brain and spinal cord.

D. controls involuntary responses.

3. Identify two components of the central nervous system. **[2 marks]**

4. Outline the role of the central nervous system. **[4 marks]**

5. Identify two divisions of the autonomic nervous system. **[2 marks]**

6. Outline the role of the somatic nervous system. **[4 marks]**

7. Outline the role of the autonomic nervous system. **[4 marks]**

EXAM NOTES 2

Neurons and Synaptic Transmission

AQA specification for Topic 5: Biopsychology

- The structure and function of sensory, relay, and motor neurons. The process of synaptic transmission, including reference to neurotransmitters, excitation and inhibition.

Introduction

The nervous system is made up of **neurons.** These are specialist cells that carry electrical impulses. Their function is to receive information and transmit this to the brain, as well as to other neurons throughout the body. There are thought to be around 100 billion neurons in the brain and one billion neurons in the spinal cord.

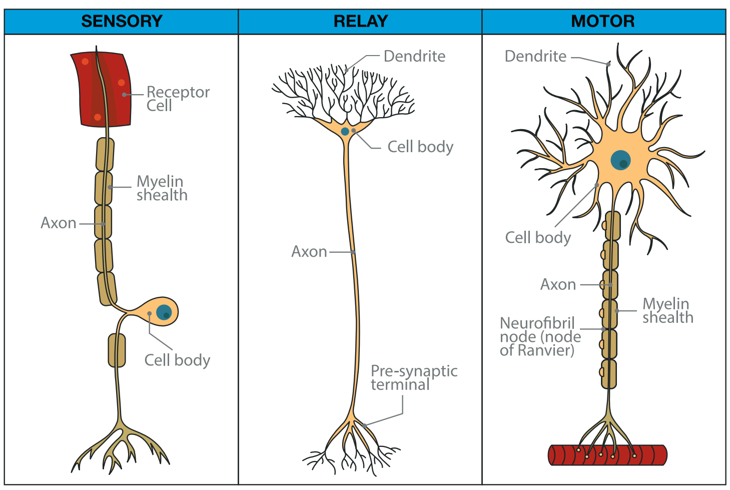
The structure and function of the neuron

Neurons are responsible for everything we do – our thoughts, memories, emotions, physical sensations and the co-ordination of all the physical functions of the body. The nervous system (including the brain) has three main types of neurons - *sensory neurons*, *relay neurons* and *motor neurons*, and they perform different functions.

Functions

- **Sensory neurons** (the 'sensing' neurons) respond to stimulation from our five senses, i.e. vision, smell, taste, touch and hearing. These neurons are located in the peripheral nervous system (PNS) and are found all over the body. They receive information from the sensory receptors (e.g. in the skin, tongue and eyes) and convert this information into electrical impulses. When these impulses reach our brain, they are translated into sensations such as pain, sight or heat. Not all sensory information travels to the brain, however. Some neurons terminate in the spinal cord. This allows reflex actions to occur quickly without the delay of sending impulses to the brain. So *sensory neurons carry signals towards the CNS (spinal cord and brain).*
- **Motor neurons** (the 'moving' neurons) are located in the central nervous system (CNS), from the brain stem nerves to the muscles of the face and head, and from the spinal cord nerves to the muscles and glands. Motor neurons help both glands and muscles to function; for example, they make muscles contract and keep the heart beating. So *motor neurons carrying information away from the CNS*
- **Relay neurons** (the 'connecting' neurons) connect motor neurons and sensory neurons, allowing them to communicate by passing signals to one another, that is, they transmit messages from one neuron to another neuron. They can also receive signals from other relay neurons. In fact, *most* relay neurons are found in the CNS. These neurons help the brain to process information from the environment.

Figure 11: Structure of typical neurons



The structure of neurons

- All three types of neurons have the same components (dendrites, cell body, axon, etc.) but they differ in their shapes, locations and the roles they play.

How information is passed within a neuron

- All three neurons have what is known as **dendrites** (receptors at one end of the neuron). The dendrites receive information from sensory receptors or other neurons. The dendrites then pass the information to the **cell body** and then on to the **axon** and the **axon terminals** at the other end of the neuron. Information travels down the neuron as an **electrical signal**, ready to be passed onto the next neuron. The **myelin sheath** is an insulating layer that forms around the axon. This helps the signal to be transmitted more rapidly. If this sheath is damaged, the signals slow down.

Synaptic transmission

How messages are transferred from one neuron to the next

Synaptic transmission is the sending of messages from one neuron to the next neuron or to body tissue (e.g. muscle). Once an electrical signal has arrived at the axon terminal, it needs to be transferred to another neuron. Here's how it works:

1. Initially, the signal (electrical impulse) travels down the neuron where it reaches the **presynaptic terminal** (which is at the very end of the axon terminal). Each neuron is separated from the next neuron by a tiny *gap* called a **synapse** (or synaptic fluid or synapse cleft).
2. When an electrical impulse reaches the end of the neuron, this activates the presynaptic terminal to release chemicals (neurotransmitters) from tiny sacs known as **vesicles**. The vesicles are found at the end of the axon, and cluster near the axon terminal. These sacs spill the neurotransmitters into the synaptic fluid/cleft.
3. These chemicals diffuse across the gap and are taken up by the adjacent neuron receptors on the dendrites of the next neuron. The **postsynaptic neuron** then converts these chemicals back into an electrical impulse to travel down the neuron to the next presynaptic terminal. *So, signals in the synapse are transmitted chemically.* In this way, the electrical impulse continues to be transmitted to the next neuron. This is how information travels.

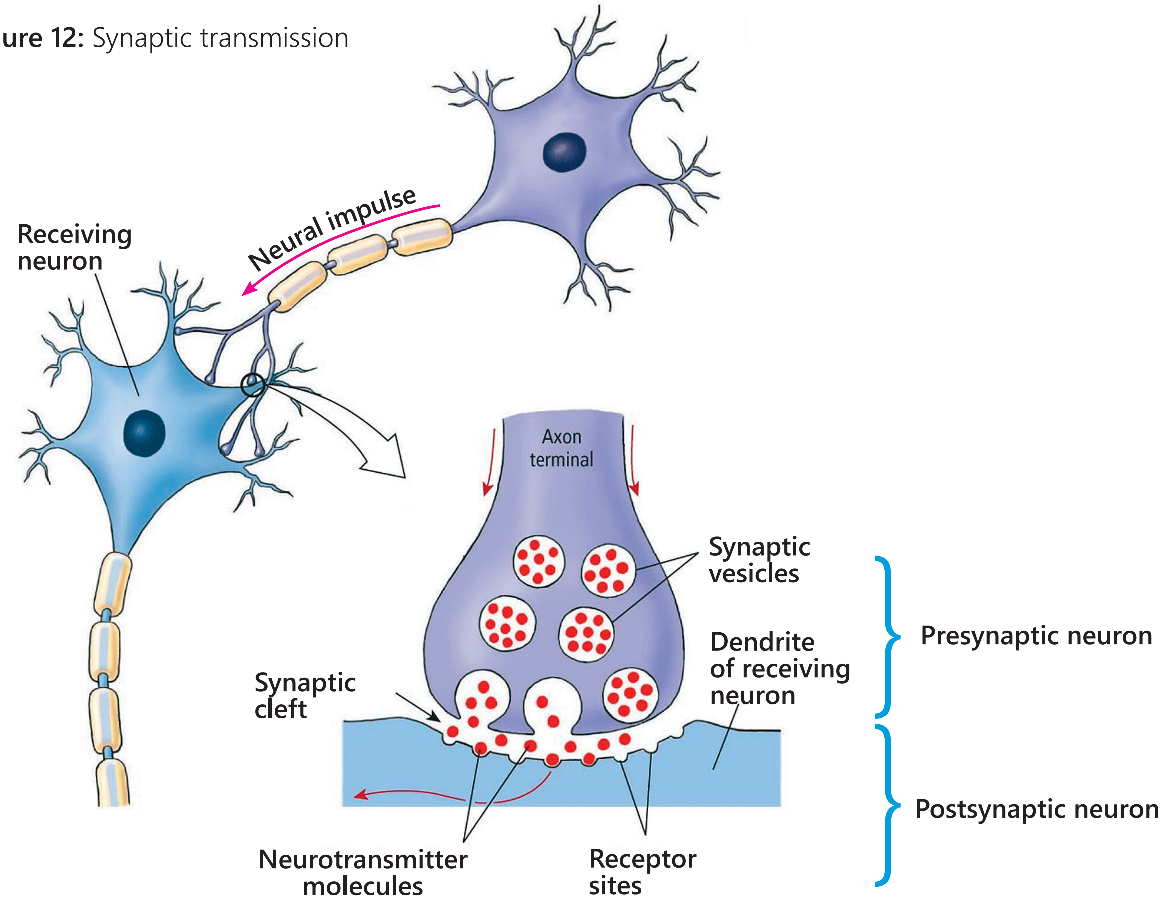
During the transmission from one neuron to another, different receptors respond to different neurotransmitter molecules. Each neurotransmitter has a specific molecular structure that fits perfectly into a postsynaptic receptor site. The neurotransmitter will attach itself to the receiving postsynaptic receptor that recognises it. This is a 'lock and key' effect. Different receptors will only accept specific neurotransmitter molecules. The whole process takes a fraction of a second. After the neurotransmitters are received, the presynaptic neuron *re-absorbs* whatever is left in the synapse and stores it to be used again later. This re-absorption (cleaning up-process) is known as **re-uptake.** It refers to the process in the brain of neurons retrieving chemicals that were not received by the next neuron.

Excitatory and inhibitory neurotransmitters

Neurotransmitters are chemical messengers that are released from vesicles on the presynaptic neuron. They carry signals from the presynaptic neuron to the postsynaptic neuron. After release, the neurotransmitter crosses the synaptic gap and attaches to the receptor site on the other neuron, either 'exciting' or 'inhibiting' the receiving neuron, depending on the type of neurotransmitter. So, neurotransmitters can be classified either as **excitatory** or as **inhibitory** in their action (some neurotransmitters can be both). How the receiving neuron will act depends on what kind of neurotransmitter it is.

- **Excitatory neurotransmitters** (e.g. acetylcholine or noradrenaline) increase the likelihood that an 'excitatory signal' is sent to the postsynaptic cell. This means the receiving postsynaptic neuron is more likely to fire and generate an electrical impulse.
- **Inhibitory neurotransmitters**. If an inhibitory neurotransmitter (e.g. GABA or serotonin) is sent, this decreases the likelihood of the receiving postsynaptic neuron firing and generating an electrical impulse.

Figure 12: Synaptic transmission



Practice exam questions

1. Explain the difference between a motor neuron and a relay neuron. **[2 marks]**
2. Briefly outline the process of synaptic transmission. **[2 marks]**
3. Briefly describe the structure of a neuron. **[3 marks]**
4. With reference to neurotransmitters, explain what is meant by 'excitation' and 'inhibition'. **[3 marks]**
5. Explain why neurons can only transmit information in one direction at a synapse. **[3 marks]**
6. Explain the process of synaptic transmission. **[5 marks]**
7. You are walking in the park, when a dog suddenly jumps forward and tries to attack you. The owner manages to control the dog and they walk away. Your breathing quickens, your mouth is dry and you have a feeling of 'butterflies' in your stomach. After a few minutes, these physical changes start to disappear. Using your knowledge of the body's response to stress, explain what you are likely to have experienced

   H. The changes that occurred in the first 30 seconds;

   I. The changes that occurred after a few minutes. **[2 + 2 marks]**