PSYCHOLOGY1001 (PSYC1001) - Neuroscience

Topic Questions

1. What is the main cause of chronic disability in Australia?
2. How do these techniques contribute to our knowledge of the relationship between biology and psychology:
   a. Lesions
   b. Recording of neurons by electrode or EEG
   c. Stimulating the CNS with electrodes or TMS
   d. Imaging the brain with PET, MRI and fMRI
3. To remember the main anatomical direction terms
4. What are the main types of nerves in the peripheral nervous system? How do they differ?
5. These structures are in the CNS. Identify and name the main functions of:
   a. Spinal cord
   b. Meninges and Ventricles
   c. Hindbrain
   d. Cerebellum
   e. Basal ganglia
   f. Limbic system
   g. Thalamus and hypothalamus
   h. Neocortex
   i. Corpus collosum
6. What is the neuron doctrine?
7. How does a nerve's membrane stay electrically polarized?
8. Describe the initiation and termination of the action potential, and how it travels across a nerve membrane.
9. How do nerves communicate with each other?
10. What are the different types of agonist and antagonist drugs?
11. What neurochemical systems do these drugs affect?
    a. Cocaine
    b. Amphetamine
    c. Heroin
    d. Benzodiazepines
    e. Ecstasy
    f. Cigarettes
    g. Alcohol
    h. Caffeine
12. Name the major components of the limbic system and associated cortical areas named below, and be familiar with the main functions of the limbic system in emotion:
    a. The hypothalamus
    b. The amygdala
    c. The cingulate cortex
    d. The insula cortex
    e. The prefrontal cortex
13. Why is depression thought to be a monoamine disease?
14. What is the mesolimbic dopamine system and what is its role in emotion and motivation?
15. What are the major functions of the frontal lobes?
16. What happened to Pinease Gage after his accident?
17. What happened to HM after his surgery?
18. What types of memory do the hippocampus and amygdala mediate respectively?
19. What are the main signs of Alzhiemer's disease, psychologically and pathologically?

1. Mental illness
2. a. relationship between behavioural changes in those who have suffered damage in specific brain areas
   b. Allows for the mapping of brain activity
   c. Monitor brain activity in specific structures of the brain
   d. Monitor brain activity as well as map brain structure

3. –
4. Somatic (voluntary) and autonomic (involuntary actions)
5. a. Connect brain to PNS
   b. 3 membranes of connective tissue, cavities in the skull filled with cerebrospinal fluid. Protect brain and CNS
   c. Provides a connection between the brain and spinal cord
   d. Structure that coordinates fine muscle movement, balance
   e. Important for action and thought
   f. major system for emotion and memory
   g. relay centre, regulates basic biological needs
   h. allows for complex thought and ability to think
   i. Bridge of fibers passing information between the two cerebral hemispheres
6. neurons are discrete and autonomous cells that can interact, synapses are gaps that separate neurons, information is transmitted in one direction, from dendrite to axon
7. the resting potential of nerves is negatively charged
8. channels in the cell membrane are opened to let sodium in upon an action potential and close afterwards
9. nerves communicate in the synapse
10.
11. a. Monoamines – catecholamines - dopamine
    b. Monoamines – catecholamines - dopamine
    c. Peptides – opioids - endorphins
    d. Amino acids – inhibitory - GABA
    e. Monoamines – indolamines - serotonin
    f. Cholines - acetylcholine
    g. Amino acids – inhibitory - GABA
    h. Nucleosides – purine - adenosine
12. hypothalamus, hippocampus, amygdala, olfactory bulb, cingulate gyrus – regulation of emotion, memory and motivation, also rich in pleasure centers
    a. controls the autonomic nervous system, links brain and endorcrine system. Source of hormonal regulation, motivational control
    b. sends outputs to many subcortical structures that control emotional arousal,
    c.
    d. generates disgust
    e. contributes to higher-order functions such as working memory, reasoning about relations between objects, etc…
13. the large success in treating depression with drugs that increase synaptic 5HT, NA or DA such as re-uptake inhibitors and monoamine oxidase inhibitors. Multiple links between depression and anxiety
14. important for motivation of behaviour, increases reward or pleasure seeking, not the experience of pleasure
15. Planning and executive functions
16. he was free from pain
17.
18. amygdala – fear response, hippocampus – declarative memory
19. loss of brain tissue in cortex, brain tissue full of senile plaques, neurofibrillary tangles

Mental Illness

Mental illness is the major contributor to chronic disability in Australia with:

- **One in five** Australians will experience some form of mental disorder every year
- **One in four** of these will experience more than one mental disorder
- Depression and anxiety are the most prevalent mental disorders
- The majority of mental illnesses begin between the ages of 15-25
- Approximately **two thirds** of people with mental illness do not receive treatment in any 12 month period
- Mental disorders and suicide account for **14.2%** of Australia's total health burden

The Utility of Neuroscience

Neuroscience assumes that the cause of psychological phenomena is the stuff that generates it i.e. the CNS. Franz Joseph Gall was the first to relate structure to function and popularized the idea that parts of the CNS may be specialised for particular mental function.

Measuring the activity of a single neuron
Nervous communication – excitable cells whose activity is closely related to input and outputs.

Neurons and Glial Cells

The nervous system is composed of cells. The cells in the nervous system fall into two major categories: neurons and glia.

Neurons:

- **Neurons** are individual cells in the nervous system that receive, integrate, and transmit information. They are the basic links that permit communication within the nervous system. A small minority receive signals from outside the nervous system
- **Soma**, or cell body, contains the cell nucleus and much of the chemical machinery common to most cells. The rest of the neuron is dedicated to handling information
- **Dendrites** are the parts of a neuron that are specialised to receive information. Most neurons have extensive dendrite trees
- The **axon** is a long, thin fiber that transmits signals away from the soma to other neurons or to the muscles or glands
- Axons are wrapped in myelin. The **myelin sheath** is insulating material that encases some axons and that acts to speed up the transmission of signals that move along axons. Multiple sclerosis is due to deterioration of the myelin sheath.
- The axon ends in a cluster of **terminal buttons**, which are small knobs that secrete chemicals called neurotransmitters. These chemicals serve as messengers and may activate nearby neurons.
- The points at which neurons connect are called synapses. **A synapse** is a junction where information is transmitted from one neuron to another.

Glia:

- **Glia** are cells found throughout the nervous system that provide various types of support for neurons. Glial cells account for about 50% of the brains volume
- **Glial cells** supply nourishment to neurons, help remove neuron's waste products and provide insulation around axons.
- **Glial cells** also play a role in the development of the CNS in the embryo.

The Neural Impulse

The neural impulse is a complex electrochemical reaction. Both inside and outside the neuron are fluids containing electrically charged atoms and molecules called ions. **Positively charged sodium and potassium ions and negatively charged chloride ions** flow back and forth across the cell membrane but they do not cross at the same rate. The difference leads to a slightly higher concentration of negatively charged ions inside the cell. The **resting potential** of a neuron is its stable, negative charge when the cell is inactive.

An **action potential** is a very brief shift in a neuron's electrical charge that travels along an axon. This occurs when positively charged sodium ions rush into the cell. After the firing of an action potential, the channels in the cell membrane that opened to let in sodium close up. Some time is needed before they are read to open again. The **absolute refractory period** is the minimum length of time after an action potential during which another action potential cannot begin.

The **all or none law** states that the neural impulse fires or it doesn't and its action potentials are all the same size. Weaker stimuli do not produce smaller action potentials. Neurons can convey information about the strength of stimuli.

The Neural Impulse

The neural impulse functions as a signal, which is transmitted at synapses, which depend on chemical messengers. At synapses, neurons do not actually touch; they are separated by the synaptic cleft. The neuron that sends the signal is called the **presynaptic** neuron while the **postsynaptic** neuron receives the signal. Action potentials trigger **neurotransmitters** (chemicals that transmit information from one neuron to another). These chemicals are stored in synaptic vesicles.

Neurotransmitters and Behaviour

The nervous system relies on neurotransmitters to communicate information and is therefore fundamental to behaviour. Some common neurotransmitters and their relations to behaviour are below.

Neurotransmitter	Characteristics and Relations to Behaviour	Associated Disorders
Acetylcholine (Ach)	• Released by motor neurons controlling skeletal muscles • Contributes to the regulation of attention, arousal and memory • Some Ach receptors stimulated by nicotine	Alzheimer's disease
Dopamine (DA)	• Contributes to control of voluntary movement • Cocaine and amphetamines elevate activity at DA synapses • Dopamine circuits in medial forebrain bundle characterized as 'reward pathway'	Parkinsonism Schizophrenic disorders Addictive disorders
Norepinephrine (NE)	• Contributes to modulation of mood and arousal • Cocaine and amphetamines elevate activity at NE synapses	Depressive disorders
Serotonin	• Involved in regulation of sleep and wakefulness, aggression • Prozac and similar antidepressant drugs affect serotonin circuits	Depressive disorders Obsessive-compulsive disorders Eating disorders
GABA	• Serves as widely distributed inhibitory transmitter, contributing to regulation of anxiety and sleep/arousal • Valium and similar antianxiety drugs work at GABA synapses	Anxiety disorders
Glutamate	• Serves as widely distributed excitatory transmitter • Involved in learning and memory	Schizophrenia
Endorphins	• Resemble opiate drugs in structure and effects • Play role in pain relief and response to stress • Contribute to regulation of eating behaviour	

An **agonist** is a chemical that mimics the action of a neurotransmitter whereas an **antagonist** is a chemical that opposes the action of a neurotransmitter.

The Nervous System

The nervous system consists of the **central nervous system** and **the peripheral nervous system**. The peripheral nervous system is made up of all those nerves that lie outside the brain and spinal cord. **Nerves** are bundles of neuron fibers (axons) that are routed together in the peripheral nervous system. The peripheral nervous system is composed of two primary systems: **the somatic nervous system** and **autonomic nervous system**.

Somatic Nervous System	• Made up of nerves that connect to voluntary skeletal muscles and to sensory receptors • These nerves carry information from receptors to the CNS. This requires two types of nerves • Afferent nerve fibers are axons that carry information inward to the CNS from the periphery of the body • Efferent nerve fibers are axons that carry information outward from the CNS to the periphery of the body.
Autonomic Nervous System	• Controls involuntary actions. It is made up of nerves that connect to the heart, blood vessels, smooth muscles and glands. • This system controls much of the physiological arousal associated with emotions • The autonomic nervous system can be subdivided into two branches • The sympathetic division is the branch of the autonomic nervous system that mobilizes the body's resources for emergencies i.e. pupil dilation, increased secretion of sweat • The parasympathetic division is the breach of the autonomic nervous system that generally conserves bodily resources i.e. slow heart rate, promote digestion
Brain	• The brain integrates information from inside and outside the body, coordinates the body's actions and enables humans to think. Hollow cavities in the brain called ventricles contain cerebrospinal fluid.
Spinal Cord	• The spinal cord connects the brain to the rest of the body through the peripheral nervous system.

Examining the Brain

The structure of the brain is easy to map. Mapping brain function is harder as it requires a working brain. Mapping brain function relies heavily on electrical recordings, lesioning and electrical stimulation. More recently, transcranial magnetic stimulation and brain-imaging techniques, such as CT and MRI scans, have enhanced neuroscientist's ability to study brain structure and function.

Electrical Recordings	The electrical activity of the brain can be recorded. The **electronencephalograph (EEG)** is a device that monitors the electrical activity of the brain over time by means of recording electrodes attached to the surface of the scalp. Recording electrodes attached to the surface of the scalp permit the EEG to record electrical activity in the cortex over time. The EEG provides **output** in the form of line tracings called **brain waves.**
Lesioning	Lesioning involves destroying a piece of the brain. It is typically done by inserting an electrode into the brain structure and passing a high-frequency electric current through it to burn the tissue and disable the structure. Scientists insert the electrode deep into the brain using stereotaxic instruments.
Electrical Stimulation of the Brain	**Electrical stimulation of the brain (ESB)** involves sending a weak electric current into a brain structure to stimulate or activate it. The electric current does not exactly duplicate brain function however it is usually a close enough approximation to activate the brain structures in which the electrodes are lodged. The same procedure is used as lesioning except with a different current.
Transcranial Magnetic Stimulation	**Transcranial Magnetic Stimulation (TMS)** is a new technique that permits scientists to temporarily enhance or depress activity in a specific area of the brain. Magnetic pulses are delivered to a localized area of the brain from a magnet mounted on a small panel. The magnetic field only penetrates to a depth of 2cm. This can be used to increase or decrease the excitability of affected neurons.

Brain-Imaging procedures

The invention of new brain-imaging devices has led to spectacular advances in science's ability to look into the brain.

Computerised Tomography Scan	CT scans are computer enhanced x-rays of brain structure. Multiple x-rays are shot from many angles and the computer combines the readings to create a **vivid image** of a **horizontal slice** of the brain. The entire brain can be visualized by assembling a series of images representing successive slides.
Positron Emission Tomography Scan	PET scans are used to map brain activity rather than brain structure. They provide color-coded maps that show areas of high activity in the brain over time. Whereas CT scans can only portray brain structure, PET scans can examine brain function, mapping actual activity in the brain over time.
Magnetic resonance imaging scan	MRI scans can be used to produce remarkably high-resolution pictures of brain structure. MRI scans use magnetic fields, radio waves and computerized enhancement to map out brain structure. MRI scans provide much better images of brain structures than CT scans, **producing 3D images** of the brain that have **high resolution**.
Functional Magnetic Resonance Imaging	fMRI is a new variation on MRI technology that monitors blood flow and oxygen consumption in the brain to identify areas of high activity. This technology, like PET scans, can map activity in the brain over time but with greater precision.

The Brain and Behaviour

The brain can be divided into three major regions: the hindbrain, the midbrain and the forebrain. These regions can be found easily in relation to the brainstem.

The hindbrain	The hindbrain includes the cerebellum and two structures found in the lower part of the brainstem: the medulla and the pons. The medulla regulates functions such as breathing and circulation. The cerebellum is involved in motor coordination and balance. The pons contributes to sleep and arousal.	Medulla Pons Cerebellum
The midbrain	The midbrain is the segment of the brainstem that lies between the hindbrain and the forebrain. The midbrain contains an area that's concerned with integrating sensory processes such as vision and hearing. Running through both the hindbrain and the midbrain is the reticular formation.	Reticular Formation
The forebrain	The forebrain is the largest and most complex region of the brain, encompassing a variety of the structures, including the thalamus, hypothalamus, limbic system and	Amygdala Thalamus Hypothalamus