PSYC 221
Introduction to General Psychology

Session 2 – Biological foundations of behaviour

Lecturer: Dr. Joana Salifu Yendork, Psychology Department
Contact Information: jyendork@ug.edu.gh
One of the intriguing issues in psychology is the understanding of factors that control human behaviors. In this session, we will focus on the biological foundations of our everyday behavior. As Myers (2007, p.35), simply puts it, “everything psychological—every idea, mood, every urge— is simultaneously biological”. Human behavior is controlled by certain biological elements, made up of the neurons, the nervous system (central and peripheral nervous system) and the endocrine system.
The key topics to be covered in the session are as follows:

• The neuron
  – Glial cell

• The nervous systems
  – Central nervous system
  – Peripheral nervous system

• The endocrine system

• Genes, Evolution, and Behavior
Reading List

• Chapter 2 of Feldman (2007), *Essentials of Understanding Psychology*.
• Chapter 5 of Myers (2008), *Exploring Psychology*.
Topic One

THE NEURON
The neuron

- Neurons are the basic elements of the nervous system and are involved in controlling behavior.
- There are about 1 trillion neurons throughout the body (Boahen, 2005).
- There are several types, that vary in size and shape but function to receive and transmit information.
- The cell body contains the nucleus.
- The nucleus contains the heredity information that determine how a cell will function.
- The structure of a typical neuron is illustrated in the figure below.
Structure of the neuron: Adopted from Myers (2008)
The neuron

- There are three types:
  - Sensory (afferent) neurons:
    - Carry messages from sense organs to the spinal cord or brain
  - Motor (efferent) neurons:
    - Carry messages from the spinal cord or brain to the muscles and glands
  - Interneurons (association neurons):
    - Carry messages from one neuron to another
Glial cells/glia

- The nervous system also contain glial cells
  - Hold neurons in place
  - provide nourishment
  - remove waste
  - Help repair damage
  - Prevent harmful substances from passing from the bloodstream into the brain
  - Form the myelin sheath
How neurons fire

• Neurons follow the all-or-none principle: they either fire by transmitting electrical impulses or don’t fire

• Before they are triggered, they remain in the resting state (resting potential): the state of a neuron when not engaged in an action potential.
  – Greater positive ions outside the cell membrane and greater negative ions inside the cell
  – Polarization: inside of neuron is negatively charged relative to the outside

• When a neuron receives a message, neural impulse (action potential) moves from one end of the axon to the other

• As the impulse travels along the axon, the movement of the ions cause a change in charge from negative to positive in successive sections of the axon
How neurons fire

• After the impulse has passed through a particular section of the axon, positive ions are pumped out of that section, then its charges returns to negative while the action potential continues to move along the axon

• After firing, the neurons goes into an absolute refractory period
  – a period after firing when a neuron will not fire again no matter how strong the incoming message

• After firing, if the Neurons incoming message is much stronger than usual, the neuron can go into a relative refractory period (a period after firing when a neuron will fire again)

• Watch video

• https://youtu.be/A9Xru1ReRwc
The Synapse

1. Synaptic vesicles in the terminal buttons of a sending neuron release neurotransmitters into the synaptic space.

2. The neurotransmitters cross the synaptic space to the receiving neuron.

3. After crossing the synaptic space the neurotransmitters fit into receptor sites located on the dendrites or cell body of the receiving neuron.
The Synapse

- Synapse is the space between two neuron where axons (sending neurons) and dendrites (receiving neurons) communicate using chemical messages (Neurotransmitters)
- Neurotransmitters carry message across the synapse to the dendrites of the receiving neuron
- Synaptic transmission
  - Neurotransmitter molecules, released by synaptic vesicles, cross the tiny synaptic space (or cleft) between an axon terminal (or terminal button) of a sending neuron and a dendrite of a receiving neuron
  - The neurotransmitters cross the synaptic space.
  - Here they latch on to receptor sites, much as keys fit into locks, and pass on their excitatory or inhibitory messages
<table>
<thead>
<tr>
<th>Neurotransmitter</th>
<th>Function</th>
<th>Examples of Malfunctions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetylcholine (ACh)</td>
<td>Enables muscle action, learning, and memory.</td>
<td>With Alzheimer’s disease, ACh-producing neurons deteriorate.</td>
</tr>
<tr>
<td>Dopamine</td>
<td>Influences movement, learning, attention, and emotion.</td>
<td>Excess dopamine receptor activity linked to schizophrenia. Starved of dopamine, the brain produces the tremors and decreased mobility of Parkinson’s disease.</td>
</tr>
<tr>
<td>Serotonin</td>
<td>Affects mood, hunger, sleep, and arousal.</td>
<td>Undersupply linked to depression; Prozac and some other antidepressant drugs raise serotonin levels.</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>Helps control alertness and arousal.</td>
<td>Undersupply can depress mood.</td>
</tr>
<tr>
<td>GABA (gamma-aminobutyric acid)</td>
<td>A major inhibitory neurotransmitter.</td>
<td>Undersupply linked to seizures, tremors, and insomnia.</td>
</tr>
<tr>
<td>Glutamate</td>
<td>A major excitatory neurotransmitter; involved in memory.</td>
<td>Oversupply can overstimulate brain, producing migraines or seizures (which is why some people avoid MSG, monosodium glutamate, in food).</td>
</tr>
</tbody>
</table>
Topic Two

THE NERVOUS SYSTEMS
The nervous system

- The body’s electrochemical communication system

- The nervous system has two parts:
  - The central nervous system (CNS) consist of the brain and the spinal cord
  - The peripheral nervous system (PNS) is made up of nerves that spread out throughout the body, linking all of the body's parts to the CNS
The nervous system

- **Central** (brain and spinal cord)
  - Peripheral
    - **Autonomic** (controls self-regulated action of internal organs and glands)
      - Sympathetic (arousing)
      - Parasympathetic (calming)
    - **Somatic** (controls voluntary movements of skeletal muscles)
The structure of the brain

• Hindbrain
  – Medulla: Controls breathing, heart rate, blood pressure
  – Pons: Regulation of sleep/wake cycle
  – Cerebellum: Involved in balance and coordination of movement

• Midbrain
  – The relay point for hearing and vision
  – One of the places pain is registered
  – Brain structures found in midbrain: superior colliculus, inferior colliculus, substantia nigra

• Forebrain structures
  – Thalamus: Sensory switchboard
  – Hypothalamus: Governs motivational (hunger, thirst, sex, sleep, and temperature control) and emotional responses

• Reticular formation
  – A network of neurons in the hindbrain, midbrain, and part of the forebrain
  – The primary function of this network is to alert and arouse the higher parts of the brain
The structure of the brain
The limbic system

- Limbic system
  - System of loosely connected structures located between the central core and the cerebral hemispheres
  - Linked primarily to memory, emotions, drives
  - Play a key role in times of stress
  - Hippocampus: Aids in the processing of memory for storage
  - Amygdala: Involved in fear and aggression
  - Hypothalamus: Bodily maintenance functions and pleasurable rewards
Structure of the limbic system
Cortex

- 3 mm. thick
- 80% of total brain volume
- Convoluted (folded, wrinkled) structure enables more tissue to fit
- The cortex provides flexibility in behavior
- Divided into 2 hemispheres and 4 paired lobes: frontal, temporal, occipital, parietal
- Localization: each structure has a somewhat different set of tasks and skills
- Multiple structures needed to perform complex tasks
Structure of the cerebral cortex

Lobes define broad divisions of the cerebral cortex.

The brain has left and right hemispheres.

Cerebral cortex is the brain’s outer “bark” layer.
Cortex

- Regulates complex behavior, including receiving sensations, motor control and higher mental processes (i.e., thinking, personality, emotion, memory, motivation, creativity, self-awareness, reasoning, etc.)
- Divided into four lobes:
  - Frontal Lobes—receive and coordinate messages from other lobes as well as motor control, speech and higher functions
  - Parietal Lobes—receives information about pressure, pain, touch and temperature
  - Temporal Lobes—hearing, language comprehension, memory and some emotional control
  - Occipital Lobes—vision and visual perception
Lateralization

• The Cerebral Cortex is divided into two hemispheres (left and right) connected by the *Corpus Collosum*

• Each hemisphere receives and sends information to the opposite side of the body

• Each hemisphere also specializes in certain functions

• Left:
  – Language: speaking, reading, writing, and comprehension
  – Analytical function: mathematics, physical science

• Right: facial and pattern recognition
  – Non-verbal abilities (music, art, perceptual and spatial manipulation, facial recognition)
  – Some language comprehension
Brain plasticity

• Definition: “Subject to alteration”
• Historically, the nervous system was deemed NOT plastic
• Recent evidence shows that neurons can change, form new connections with other neurons.
• As a result, the brain itself can also change.
How to study the brain

• Neuroscience is the field that focuses on studying the nature, functions, origins of the nervous system

• Clinical observation
  – The story of Phineas Gage: frontal lobe damage

• Neuropsychology
  – what happens to behavior when brain structures are damaged

• Experimental techniques
  – Lesioning brain structures, observing consequences
  – Transcranial magnetic stimulation: temporary loss of brain function in isolated areas near surface of brain (just under scalp)
How to study the brain

- Microelectrode techniques: Used to study the functioning of a single neuron
- Macroelectrode techniques: Used to measure cortical activity (e.g., EEG)
- Structural imaging: studying the structure of the brain
  - Computerized Axial Tomography scanning (CT)
  - Nuclear Magnetic Resonance Imaging (MRI)
- Functional imaging: studying the function of the nervous system
  - Electroencephalograph (EEG)
  - Magnetoencephalography (MEG)
  - Magnetic Source Imaging (MSI)
  - Positron Emission Tomography (PET) scanning
Studying the brain

- Nuclear Magnetic Resonance Imaging (NMR or MRI)
  - An MRI uses alterations in the electromagnetic field of the body created by a magnet to measure the movement of nuclei as they return to their original axes

- Computerized Axial Tomography (CAT or CT) scanning
  - An X-ray photography unit passes a radioactive ray through bone and brain tissue to show structures of the brain

- Electroencephalograph (EEG)

- Positron Emission Tomography (PET) scanning
  - PET scans show actual brain activity by measuring radiation in the brain emitted from radioactive water that was injected into the bloodstream

- Magnetoencephalography (MEG), Magnetic Source Imaging (MSI)
  - These imaging techniques measure the strength of the magnetic field produced by electrical activity in order to identify its source
The spinal cord

- The spinal cord is the communications superhighway that connect the peripheral nervous system to the brain
- There are two major pathways in the spinal cord:
  - The motor neurons
  - The sensory neurons
Peripheral nervous system

- Consist of two neurons:
- Afferent neurons, which carry sensory messages to the central nervous system and
- Efferent neurons, which carry messages from the CNS
- It is also divided into two:
  - Somatic nervous system
    - Has neurons involved in making voluntary movements of the skeletal muscles
  - Autonomic nervous system
    - Has neurons involved in governing the actions of internal organs
Peripheral nervous system

- Autonomic Nervous System
- The autonomic nervous system is divided into two parts:
  - the sympathetic division, which acts primarily to arouse the body when it is faced with threat, and
  - the parasympathetic division, which acts to calm the body down, restoring it to normal levels of arousal
- Sympathetic division
  - Dilates pupils
  - No effect on tear glands
  - Weak stimulation of salivary flow
  - Accelerates heart, constricts arterioles
  - Dilates bronchi
  - Inhibits stomach motility and secretions
Peripheral nervous system

- Parasympathetic division
  - Constricts pupils
  - Stimulates tear glands
  - Strong stimulation of salivary flow
  - Inhibits heart, dilates arterioles
  - Constricts bronchi
  - Stimulates stomach motility & secretion
Peripheral nervous system

Parasympathetic Division:
- Constricts pupil
- Stimulates tear glands
- Strong stimulation of salivary flow
- Inhibits heart, dilates arterioles
- Constricts bronchi
- Stimulates stomach motility and secretion, stimulates pancreas
- Stimulates intestinal motility
- Contracts bladder
- Stimulates erection

Sympathetic Division:
- Dilates pupil
- No effect on tear glands
- Weak stimulation of salivary flow
- Accelerates heart, constricts arterioles
- Dilates bronchi
- Inhibits stomach motility and secretion, inhibits pancreas and adrenals
- Inhibits intestinal motility
- Relaxes bladder
Topic Three

THE ENDOCRINE SYSTEM
The endocrine system

• The endocrine system is made up of
• Endocrine Glands:
  – Tissues that produce and release hormones
• Hormones:
  – Chemical substances released by glands that help regulate bodily activities
The endocrine system

- Pituitary gland: Produces the largest number of the body’s hormones
- Pineal gland: Regulates one’s activity level over the course of a day
- Thyroid gland: Produces the hormone thyroxin, which regulates the body’s rate of metabolism
- Parathyroid glands: Secrete hormone which controls and balances the levels of calcium and phosphate in the blood and tissue fluids
- Pancreas
  - An organ lying between the stomach and small intestine
  - It secretes insulin and glucagon to regulate blood-sugar levels
- Adrenal glands
  - Adrenal cortex: Outer covering of the adrenal glands; Releases hormones important for dealing with stress
  - Adrenal medulla: Inner core of the adrenal glands that also releases hormones to deal with stress
- Gonads: The reproductive glands (testes and ovaries)
The endocrine system

- **Pineal gland** secretes melatonin which helps regulate sleep-wake cycles.
- **Pituitary gland**, controlled by the hypothalamus, produces a wide variety of hormones that regulate the activities of several other glands. Pituitary hormones are also involved in growth, uterine contractions during childbirth and milk production.
- **Parathyroids** regulate calcium and phosphate levels in the body, influencing excitability.
- **Thyroid gland** secretes the hormone thyroxin, which regulates the body’s metabolic rate.
- **Pancreas** regulates blood sugar levels with two hormones: insulin and glucagon.
- **Adrenal glands** consist of two glands: the adrenal cortex (the outer layer) and adrenal medulla (the inner core) secrete a variety of hormones that are involved in the body’s response to stress and arousal when physically threatened.
- **Ovaries** secrete estrogen, which organizes the development of the female reproductive system, including the secondary sexual characteristics.
- **Testes** secrete testosterone, which during prenatal growth regulates the development of the male reproductive system. Testosterone levels are also linked to sexual interest and sexual behavior in adults.
Topic Four

GENES, EVOLUTION AND BEHAVIOR
• Behavioral genetics addresses the question:
  – What is the relationship between heredity and behavior?
• Evolutionary psychology addresses the question:
  – What are the origins of behavior, and what adaptive value do they provide?
• The two fields explore the influences of heredity on human behavior
• Both contribute to the nature/nurture debate over the relative contributions of genes and the environment to human similarities and differences
Genetics

• Genetics
  – Study of how living things pass on traits from one generation to the next.

• Genes
  – Elements that control the transmission of traits; found on the chromosomes

• Chromosomes
  – Pairs of threadlike bodies within the nucleus of every cell in the human body.
  – Each contains genes.

• Deoxyribonucleic acid (DNA)
  – A complex, organic molecule. Is the main ingredient of chromosomes and genes.
  – Forms the code for all genetic information.
  – Has unique property of being able to replicate or reproduce itself, which happens every time a cell divides.
Patterns of Inheritance

- Patterns of Inheritance
  - Inheritance can occur several different ways.
- Dominant/recessive patterns of inheritance
  - Genes occur in pairs.
  - Some genes are dominant, such that a child who has that gene in either pair will show the trait.
  - Recessive genes only appear if a child has inherited two copies of it.
- Polygenic inheritance
  - Often, a single gene will contribute to more than one trait.
  - As a result, one trait will be the combination of a number of genes.
  - E.g. weight, height, skin pigmentation.
- Genotype
  - An organism’s entire genetic makeup; the genetic “blueprint.”
- Phenotype
  - Those traits that are expressed; determined by both genetics and experience.
Behavior Genetics

• A variety of methods are used to study the contribution of genes

• Animal behavior genetics
  – Strain studies: approach the problem by observing strains of highly inbred genetically similar animals
  – Selection studies: try to determine the extent to which an animal's traits can be passed on from one generation to another. They estimate the heritability of a trait by breeding animals with other animals that have the same trait.
Human behavior genetics

- Twin studies:
  - Studies of identical and fraternal twins to determine the relative influence of heredity and environment
    - Identical: Twins developed from a single fertilized ovum
    - Fraternal: Twins developed from two separate fertilized ova
  - Adoption studies
    - Research carried out on children who were adopted at birth by parents not related to them
    - The goal of this type of research is to determine the relative influence of heredity and environment on human behavior
Evolutionary psychology: Analyzes human behavioral tendencies by examining their adaptive value from an evolutionary perspective.

It has proven useful in helping to explain some of the commonalities in human behavior that occur across cultures.

Common applications of theory:
- Language, which appears cross-culturally in similar stages.
- Mate selection, in which males and females appear to use different strategies based on adaptation.

Criticisms of theory:
- Could be used to justify unjust social policies.
- Cross-cultural findings do not necessarily imply evolutionary roots to a behavior.
Sample Question

• According Myer (2007, p.64), “Biological psychologists study the links between our biology and our thoughts, feelings, and behaviors, because everything psychological is simultaneously biological”. Discuss.
References

