Perception (PSY 4204) Christine L. Ruva, Ph.D.

INTRODUCTION TO THE PHYSIOLOGY OF PERCEPTION
Chapter 2

RECEPTORS & NEURAL PROCESSING

- **Theme of Chapter: *"We do not just perceive what is out there. We perceive what is out there as filtered through the properties of our visual system."***

OVERVIEW OF QUESTIONS

- How are physiological processes involved in perception?
- How can electrical signals in the nervous system represent objects in the environment?

BASIC BRAIN STRUCTURE

- The brain has ***modular organization***
  - The sensory modalities have ***primary receiving areas***
    - Vision - occipital lobe
    - Audition - temporal lobe
    - Tactile senses - parietal lobe
  - Frontal lobe coordinates information received from two or more senses

STRUCTURE & FUNCTION OF NEURONS

- **Dendrites:** _____ from neighboring neurons and from environmental stimuli.
- **Axon:** extends from body and _____ to other neurons.
- **Synapses:** structure mediating chemical or electrical communication between neurons.
- **Terminal Buttons or Synaptic Vesicles**: small knobs at the end of the axonal branches that _____.
- **Neurotransmitters:** chemical transmission of information released from neuron.
- **Myelin:** fatty protein insulation surrounding an axon that improves the _____ of action potentials.
  - Myelination of neurons is not complete until?
  - **Nodes of Ranvier**:
  - **Multiple Sclerosis**:

STRUCTURE & FUNCTION OF NEURONS (continued)

- **Nerves:** are made up of many _____ (axons). These axons are called ***nerve fibers***.

- **Purpose** of a neuron is to transmit information to other neurons.

- **Receptors** - specialized neurons that respond to specific kinds of energy.

- Neurons come in different shape and sizes depending on **location** and **function** in the NS.

Recording Neural Signals

- Microelectrodes are used to record from single neurons.
  - Recording electrode is inside the nerve fiber.
  - Reference electrode is outside the fiber.
  - Difference in charge between them is **-70 mV** when the cell is at rest.
  - This negative charge of the neuron relative to its surroundings is the **resting potential (polarized)**.

ACTION POTENTIAL OF NEURONS

- Neurons are bathed in liquid. Thus, the neural impulse is a **"wet" electrical signal**.

- **Ions:** small electrically charged particles. The 2 types of ions (positive and negatively charged) resemble the 2 poles on a battery.
  - Sodium ions (Na^+) – positive charge
  - Chlorine ions (CL^-) – negative charge
  - Potassium ions (K^+) – positive charge

- **Membranes have selective permeability**
  - The **permeability** of the membrane changes as a result of action potentials allowing sodium and potassium to cross the membrane.

- **Action Potential (Nerve Impulse):** this is a rapid increase in positive charge (depolarization) that is caused by changes in the **membrane's permeability.**
  - **Na+** flows _____ the fiber making the neuron more _____ (rising phase).
  - **K+** flows _____ of the fiber making the neuron more _____ (downward phase) bringing the charge back to resting level.
  - **Sodium-Potassium Pump:** continuously pumps sodium to the _____ of the axon and potassium to the _____, thus maintaining sodium and potassium at their _____.

Basic Properties of Action Potentials

- **propagated response :** the action potential remains the _____ as it travels down the axon – no matter how far it travels.

- **Changing the intensity of a stimulus** does not affect the size of the action potential, but does effect the _____

- **Refractory Period:** recovery period after action potential which lasts approximately 1 millisecond (max rate of firing = 500-800 impulses per second).

- **Spontaneous Activity**: many axons fire without any _____.

Chemical & Electrical Events at the Synapse

- The action potential does **NOT** cross the synapse. It triggers the release of neurotransmitters.
  - Presynaptic neuron
  - Postsynaptic neuron

- **Lock and Key System**:

Types of Neurotransmitters

- A neuron's charge is polarized when at **rest** because the solution inside neuron is more negative than solution on the outside.
- **Excitatory transmitters** - _____
  - Neuron becomes more _____
  - _____ the likelihood of an action potential
- **Inhibitory transmitters** - _____
  - Neuron becomes more _____
  - _____ the likelihood of an action potential

NEURAL PROCESSING BY EXCITATION & INHIBITION

- **Neural Circuits** are groups of neurons connected by excitatory and inhibitory synapses.
- A **linear circuit** has _____ convergence and only excitatory inputs.
  - Input into each receptor has _____effect on the output of neighboring circuits.
  - Each circuit can only indicate single spot of stimulation.
  - Firing receptor B provides no information on length of line.

NEURAL CIRCUITS – CONTINUED

- **Convergent circuit** with only **excitatory** connections.
  - Input from each receptor _____ into the next neuron in the circuit.
  - Output from convergent system varies based on input.

- **Convergent circuit** with **excitatory** and **inhibitory** connections:
  - Inputs from receptors summate to determine output of circuit
  - Summation of inputs result in:
    - _____ for single inputs & long stimuli
    - _____ for medium length stimulus (size info)

RECEPTIVE FIELDS

- **Receptive Fields**: the area of the retina that, when stimulated, influences the firing rate of ganglion cells.

- Receptive fields are determined by monitoring single cell responses.

- Stimulus is presented to retina and response of cell is measured by an electrode.

- Both excitatory areas and inhibitory areas make up the neuron's receptive field.
  - **Excitatory or On response** – _____
  - **Inhibitory or Off response** - _____

- **Center-surround receptive fields** are arranged with a center area that responds one way and a surround area that acts another.
  - Excitatory-center-Inhibitory surround
  - Inhibitory-center-Excitatory surround

Center-Surround Antagonism

- Output of center-surround receptive field changes depending on area stimulated:
  - **Highest** response when _____ is stimulated
  - **Lowest** response when _____ is stimulated
  - **Intermediate** responses when _____ are stimulated

Sensory Code: Representation of Environment

- **Sensory code** - representation of perceived objects through neural firing
  - **Specificity coding** - specific neurons responding to specific stimuli
- Leads to the _____ hypothesis
- Recent research shows cells in the _____ that respond to concepts such as Halle Berry.

Sensory Code: Representation of Environment – continued

- **Problems with specificity coding**:
  - _____ to assign specific neurons
  - Most neurons respond to _____.

- **Distributed coding** - _____
  - Large number of stimuli can be coded by a few neurons.

Mind-body Problem

- How do physiological processes become transformed into perceptual experience?
  - **Easy problem of consciousness**
    - Neural correlate of consciousness (NCC) - how physiological responses *correlate* with experience
  - **Hard problem of consciousness**
    - How do physiological responses *cause* experience?

FEATURE DETECTORS

- Some neurons in the visual cortex respond only to certain types of visual information.
  - For example, a vertical line.

- These cells are called feature detectors
  - Simple cortical cell
  - Complex cortical cell
  - End-stopped cortical cell

- These are measured in a similar way as visual fields.
  - **Feature Detectors** are determined by monitoring single cell responses.
  - Stimulus is presented to retina and response of cell is measured by an electrode.

TO WHAT EXTENT DO WE LEARN TO PERCEIVE?

- **Adults who were born blind**, but gained sight later in life (Gregory, 1978; von Senden, 1932).

  - **Example: Surgery involved transplanting stem cells** onto the surface of the eye to replace the scar tissue.

  - Michael May, age 46, was **blind for 43 years** lost his vision at age **3 ½ years)** and now 3 years after surgery his right eye functions perfectly, but unless his brain catches up there is still a lot he cannot see.
    - **Sept 2003** ***Nature Neuroscience***
    - Similar experiments were conducted with cats (Weisel, 1982).

Selective Rearing Studies

- **Selective Rearing Studies**: Animals reared in specific environment
  - Limits type of stimuli present

- Blakemore & Cooper, 1970: Selective Rearing Study

  - Kittens were reared in the dark except for a period each day when they were exposed to lines of one orientation (horizontal or vertical).

  - Kittens exposed to horizontal lines had few, if any, cells that maximally responded to orientations other than horizontal.

  - Cells that were not stimulated became _____.

  - Their eyes had not degenerated and their retinas still relayed signals to their visual cortex, but lacking stimulation, the cortical cells had not developed normal connections. Thus, the animals remained _____.

Visual Development

- Severe **congenital astigmatism**
  - creates a visual environment similar to that of the _____.
  - cornea is distorted, causing the image to be out of focus in _____.
  - permanent neural changes occur - vision is impaired in one orientation.
  - must be corrected before age _____

- **Strabismus** the eyes are _____, resulting in excessive disparity between the two eyes' input to the brain.
  - one eye's input is _____.
  - loss of binocularly driven cortical cells
  - _____ impaired: critical period for binocular vision
  - after age _____ little development occurs