CHAPTER 4

Sensations & Senses

Our Senses & the World

- Characteristics of All Senses

- RECEPTION:
  - Accessory Structures: modify the energy created by something in the person’s environment

Characteristics (continued)

- TRANSDUCTION:
  - process by which a sense organ changes or transforms physical energy into electrical signals that become neural impulses and are sent to the brain
  - Sensory Receptors: (where transduction takes place) specialized cells that detect certain forms of energy

Characteristics (continued)

- ADAPTATION:
  - process by which prolonged or continuous stimulation results in a decreased response by the sense organs.

Neuronal Response

Stimulus

Time
Characteristics (continued)

- Coding:
  - the translation of the physical properties of a stimulus into a pattern of neural activity that specifically identifies those physical properties
  - Specific Nerve Energies: stimulation of a particular sensory nerve provides codes for that one sense, no matter how the stimulation takes place

Sensations vs. Perceptions

- Sensations - outcome of the brain's initial processing of electrical signals from sensory receptors
- Perceptions - outcome of the brain's next step, which is to combine these basic sensations into meaningful experiences

Purpose of Both

- Guidance of Behavior
- Visual Sensations
  - Lines, colors, texture
- Visual Perceptions
  - Seeing an object

Basic Principles of Sensory Systems

- Quality: specialized receptor cells exist to detect each distinct quality
  - e.g. tastes: salty, bitter, sweet, sour, umami
  - e.g. sounds: vary in pitch and complexity
- Quantity / Intensity: signaled by the rate of firing of the receptor cells
  - e.g. tones (loudness); lights (brightness)

Basic Principles of Sensory Systems (continued)

- Timing: sensations start at a particular moment & continue for a measurable period
  - Temporal Code
- Location: sensations may identify where in space a signal came from
  - Spatial Code

Sensory Thresholds & Signal Detection

- Absolute Threshold - weakest stimulus a person can detect half the time
- Difference Threshold - smallest change in a stimulus that produces a change in sensation (Just Noticeable Difference: JND)
Sensory Thresholds & Signal Detection

- Sensory variability can occur because:
  - The physical stimulus may vary
  - The person’s sensory system varies over time (attention, fatigue)
  - Person’s level of motivation may vary
  - Weber’s Law - the increase in stimulus intensity needed to produce a 2nd stimulus that is a JND proportional to the intensity of the 1st stimulus

Structure of the Eye

1. Cornea
2. Pupil
3. Iris
4. Lens
5. Retina

The Eye Ball

- Accommodation - ability to change the shape of the lens, making it more curved to obtain a focused image
  - Too large: nearsighted
  - Too short: farsighted

Visual Pathway: Eye to Brain

- Retina – experience of seeing begins when light waves are reflected back, enter eyes, & are focused on the retina
  - Sensory Receptors = photoreceptors specialized cells that contain photopigments

Visual Pathway: Eye to Brain (continued)

- Rods
  - Photoreceptors specialized for dim-light vision (brightness)
- Cones
  - Photoreceptors specialized for vision in light (color & detail)
Visual Pathway: Eye to Brain  
(continued)

- **Fovea (centralis)**
  - Contains only cones (greatest acuity)
- **Ganglion Cells**
  - Neurons that do the final processing of signals within the eye

Visual Pathway: Eye to Brain  
(continued)

- **Optic Nerve**
  - Formed from the axons of ganglion cells which carries impulses towards brain
  - Optic Disk – blind spot where the optic nerve exits the eyeball (no photoreceptors)
  - Optic Chiasm – junction in brain where optic nerves converge & axons are rerouted so that a crossing over of visual signals takes place

Visual Pathway: Eye to Brain  
(continued)

- **LGN (Lateral Geniculate Nucleus)**
  - A six layered grouping of cell bodies in the thalamus that accepts signals from ganglion cells and sends them to visual cortex
- **Primary Visual Cortex**
  - Located at the back of each occipital lobe
  - Transforms nerve impulses into simple visual sensations (i.e. texture, lines, colors)

Visual Pathway: Eye to Brain  
(continued)

- **Association Areas**
  - The primary visual cortex sends simple visual sensations (impulses) to neighboring association areas which add meaning
  - Assembles sensations into a meaningful image
  - Visual Agnosia
    - damage to the association area that results in difficulty recognizing objects or faces

Color Vision Theories

- **Young-Helmholtz Trichromatic Theory**
  - There are three different kinds of cones
  - Each one contains one to three different light-sensitive chemicals called opsins
  - Vision is a ratio of all three colors coded by the pattern of activity in the different cones
Color Vision Theories (continued)

- **Opponent Process Theory**
  - Ganglion cells in the retina and cells in the thalamus respond to pairs of colors
    - Red & Green, Blue & Yellow, Black & White
  - When these cells are excited, they respond to one color of the pair
  - When inhibited they respond to the complimentary pair

- **Opponent Process plus Trichromatic Theory**
  - Combination of both theories
  - Three types of cones
  - Complimentary colors & inhibition

Color Blindness

- Inability to distinguish two or more shades in color spectrum (ROYGBIV)
- Due to lack of genes
  - **Monochromats** – total color blindness (world looks like B&W movies) rare
  - **Dichromats** – have trouble distinguishing red from green because they have just two kinds of cones
    - Found mostly in males

Hearing Sound

- **Sound**
  - A repetitive fluctuation in the pressure of a medium
- **Wave**
  - A repetitive variation in pressure that spreads out in three dimensions
- **Sound Waves**
  - Stimuli for hearing or audition that travel through space with varying height (amplitude) & speed (frequency)

Hearing Sound (continued)

- **Amplitude**
  - The difference in air pressure from the baseline to the peak of the wave
- **Loudness**
  - Subjective experience of a sound's intensity with the brain calculates from specific physical stimuli (amplitude of sound waves)
Hearing Sound (continued)

- **Frequency**
  - The number of complete waves, or cycles, that pass by a given point in space every second

- **Pitch**
  - The subjective experience of a sound being high or low, which the brain calculates from physical stimuli (speed/frequency of sound waves)

Threshold for Hearing

- **Frequencies (Hertz)**
  - Infants: 20 to 20,000 Hz
  - College students: 30 to 18,000 Hz
  - ~70: many have trouble hearing >6,000 Hz

- **Decibel**
  - Unit to measure loudness

Intensity of Sound Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Sound Level dB</th>
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<tbody>
<tr>
<td>Spacecraft Launch (from 45m)</td>
<td>180</td>
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<tr>
<td>Loudest Rock Band on Record</td>
<td>160</td>
</tr>
<tr>
<td>Pain threshold (approximate)</td>
<td>140</td>
</tr>
<tr>
<td>Large jet motor (at 22m)</td>
<td>120</td>
</tr>
<tr>
<td>Loudest human shout on record</td>
<td>111</td>
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<tr>
<td>Heavy auto traffic, Walkman</td>
<td>100</td>
</tr>
<tr>
<td>Conversation (at about 1m)</td>
<td>60</td>
</tr>
<tr>
<td>Quiet Office</td>
<td>40</td>
</tr>
<tr>
<td>Soft Whisper</td>
<td>20</td>
</tr>
<tr>
<td>Threshold of Hearing</td>
<td>0</td>
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</tbody>
</table>

Auditory System

- **Outer Ear**
  - External Ear (pinna)
- **Middle Ear**
  - Picks up and amplifies vibrations and passes them on to inner ear
  - Ossicles (3 tiny bones)
    - Malleus (hammer)
    - Incus (anvil)
    - Stapes (stirrup)
- **Oval Window**
  - Receives vibrations from stapes & passes vibrations on to inner ear
Inner Ear

- Cochlea
  - Has a bony coiled exterior, contains receptors for hearing & transforms vibrations into nerve impulses (transduction)
- Hair Cells
  - These auditory receptors arise from the basilar membrane (bottom)
  - Vibration of fluid in cochlear tubes cause the movement of the basilar membrane, which bends the hair cells which triggers nerve impulses
- Auditory Nerve

Inner Ear (continued)

Auditory Areas

- Primary Auditory Cortex
  - Located at top edge of temporal lobe & transforms electrical signals into basic auditory sensations (sounds, tones)
- Auditory Association Area
  - Receives & combines meaningless auditory sensations into meaningful melodies, songs, words &/or sentences

Chemical Senses: Taste

- Taste (Gustation)
  - Four basic tastes: sweet, salty, sour & bitter, umami
  - Surface of tongue consists of narrow trenches.
    - Molecules of food mix with saliva, enter the trenches and stimulate the taste buds

Chemical Senses: Taste (continued)

- Taste Buds – receptors for taste
  - Papillae
  - Produce nerve impulses that reach areas in the parietal lobe
  - Reside in toxic environment, therefore are replaced every ten days
Chemical Senses: Taste (continued)

- All tongues are different
  - 500 - 10,000 taste buds
  - 25% of population are supertasters
  - For all, ability to taste is greatly affected by ability to smell

Chemical Senses: Taste (continued)

- Cultural Diversity – Different Taste
  - Beside an innate preference for sweet & salty taste & an avoidance of bitter substances, most of our tastes are learned.
    - Asmat of New Guinea – grubs
    - Japan – sushi
    - Eskimos – raw fish eyes; whale fat
    - East Africa – blood

Chemical Senses: Taste (continued)

- Taste & Smell
  - We experience FLAVOR when we combine sensations of taste & smell

Chemical Senses: Smell

- Smell (Olfaction)
  - 10,000 times > sensitive than taste
  - Olfactory receptors transform chemical information into nerve impulses

Chemical Senses: Smell (continued)

- Olfactory Cells
  - The receptors for smell are located in two 1-inch-square patches of tissue in upper most part of nasal passages
  - Mucus covers olfactory cells
  - Olfactory cells → olfactory bulbs → primary olfactory cortex (underneath brain) → transforms nerve impulses into olfactory sensations

Chemical Senses: Smell (continued)

- People can identify approximately 10,000 olfactory sensations
- People have approximately 1,000 different types of olfactory receptors
Chemical Senses: Smell (continued)

- Functions
  - Intensify taste of food
  - Warn us away from potentially hazardous foods
  - Elicit strong memories
  - For many animals: to locate food, mates & territory
  - Pheromones

Somatic Senses: Touch

- The sense that includes pressure, temperature, and pain
- Functions
  - To change mechanical pressure or changes in temperature into nerve impulses

Somatic Senses: Touch (continued)

- Skin
  - Outer most layer (stratum corneum)
    - Thin layer of dead cells containing no receptors
  - Middle layer (dermis)
    - Contains a variety of receptors with different shapes and functions
  - Hair Receptors

Somatic Senses: Touch (continued)

- Skin (continued)
  - Free Nerve Endings
    - Thread like extensions in the outer layers of skin which can transmit information about both temperature and pain
  - Pacinian Corpuscle
    - Largest touch sensor which has distinctive layers that are highly sensitive to touch

Somatic Senses: Touch (continued)

- Skin (continued)
  - Somato-Sensory Cortex
    - Located in parietal lobe, transforms nerve impulses into sensations of touch, temperature, and pain

Somatic Senses: Touch (continued)

- Pain (A different sense)
  - Pain arises when stimuli of various kinds activate free endings
  - The somatosensory & limbic areas of brain transform nerve impulses from pain receptors into pain sensations
    - i.e. sharp/localized or dull/generalized
Somatic Senses: Touch (continued)

- Perception of Pain
  - Can be influenced by several factors
    - Competitive impulse, attention, or emotions
    - Endorphins (morphine)
    - Acupuncture

Somatic Senses: Vestibular System

- Located above the cochlea in the inner ear
- Includes 3 semicircular canals which are set at different angles
- Functions
  - Sensing the position of the head, keeping head upright, & maintaining balance

Somatic Senses: Vestibular System (continued)

- Motion Sickness
  - Consists of feelings of discomfort, nausea & dizziness
  - Thought to develop when there is a sensory mismatch between information from the vestibular system and information reported from the eyes

- Malfunctions of the Vestibular System
  - Meniere’s disease
    - Results from the malfunctioning of semi-circular canals. Symptoms include sudden attacks of dizziness, nausea, vomiting, & head-splitting buzzing sounds
  - Vertigo
    - Results from malfunctioning of semi-circular canals. Symptoms include dizziness & nausea

Somatic Senses: Kinesthesia

- The sense that provides information about body movement and position
- Receptor cells are located in nerve endings within and near muscles, tendons & body joints