CHAPTER 4

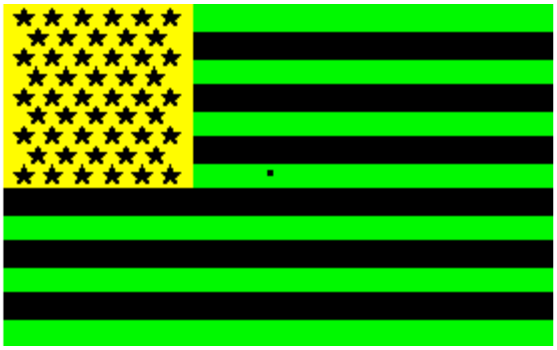
Sensations & Senses

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



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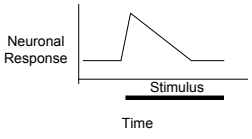
Characteristics (continued)

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



Characteristics (continued)

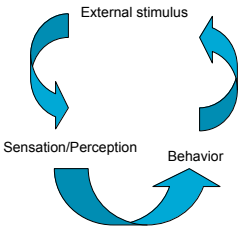
- Coding:
  - the translation of the physical properties of a stimulus into a pattern of neural activity that specifically identifies those physical properties
  - Specific Nerve Energies: stimulation of a particular sensory nerve provides codes for that one sense, no matter how the stimulation takes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

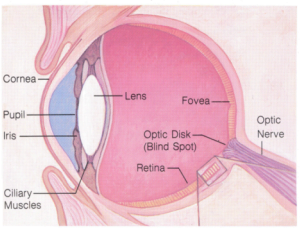
Sensory Thresholds & Signal Detection

- 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 (continued)

- 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

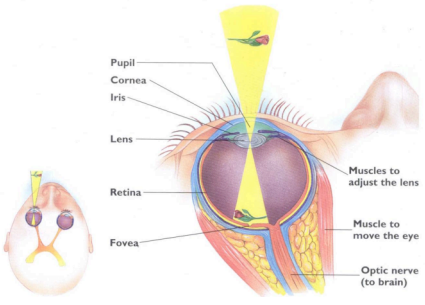
The Eye Ball

- 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)



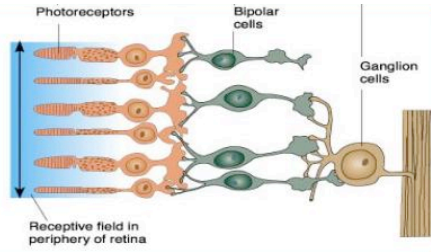
Visual Pathway: Eye to Brain (continued)

- 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)



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

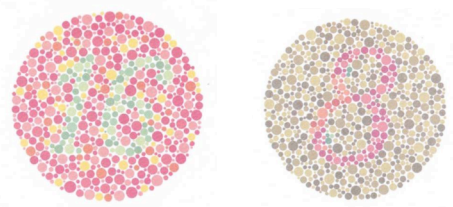
Color Vision Theories (continued)

- 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

Color Blindness (continued)



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)

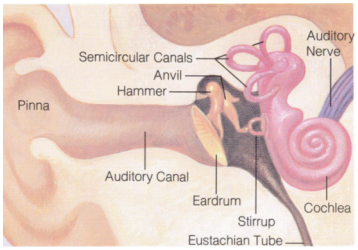
Threshold for Hearing

- 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

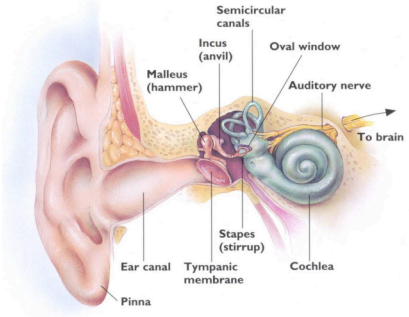
Source	Sound Level dB
Spacecraft Launch (from 45m)	180
Loudest Rock Band on Record	160
Pain threshold (approximate)	140
Large jet motor (at 22m)	120
Loudest human shout on record	111
Heavy auto traffic, Walkman	100
Conversation (at about 1m)	60
Quiet Office	40
Soft Whisper	20
Threshold of Hearing	0

Auditory System



Outer Ear
-External Ear (pinna)
-Auditory Canal
-Tympanic Membrane

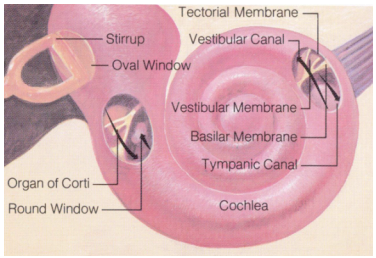
Auditory System



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

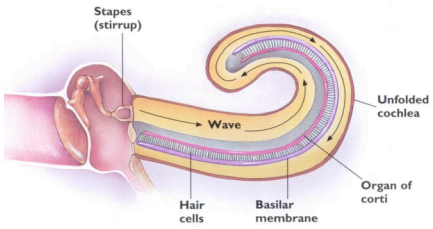


Inner Ear (continued)

- 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

-Cochlea -Basilar Membrane
-Hair Cells -Auditory Nerve



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

Somatic Senses: Vestibular System (continued)

- 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