Humans

# Senses:

* Sight (vision)
* Hearing (audition)
* Smell (olfaction)
* Taste (gustation)
* Touch (tactition)
* Balance (equilibrioception)
* Personal Body Pose (proprioception)
* Temperature
* Pain

# Vision:

* Pupil acts as an aperture and adjusts automatically to the amount of light; Lens focuses the light onto the retina; Retina senses the incident light; Optic nerve sends the encoded light information to the visual cortex in the brain.
* Human Visual Field: 220o Horizontal, 120o Vertical
* 50% of Photoreceptors Concentrated in Center (Fovea, Detail Sensitive)
* 50% of Photoreceptors Scattered in Rest of Retina (Peripheral Vision, Motion Sensitive)
* Brightness “Just Noticeable Difference” (JND):
  + The smallest difference between 2 brightness intensities that is noticeable to humans.
  + For normal computer screens, humans can see around 60 shades of grey.
* Persistence of Vision:
  + A positiveafterimage seen for a short time after the original image is removed.
  + Duration typically 1/25 - 1/5 secs, depending on intensity & duration of original image.
* Negative Afterimage:
  + Forms after extended viewing of a bright original image. Greatly depends on the intensity of the original image.
* Flicker Fusion:
  + CRT displays need to be refreshed fast (>70 Hz) to avoid flickering in the human eye and appear constantly bright.
* Color:
  + Visible light is not actually colored. Color is purely a human visual sensation.
  + Combined stimulation of different cones in human eyes leads to different colors. The aim of screens is to stimulate cones in as many different ratios as possible.
* Higher Level Visual Perception:
  + The human mind takes in visual sensations and interprets a mental model.
  + Raw Visual Sensations → Higher-Level Abstract Mental Model (Bottom-up Processes)
    - Combine low-level features or tokens into intermediate & higher-level features.
  + Higher-Level Abstract Mental Model → Raw Visual Sensations (Top-down Processes)
    - Guess or have a prior idea of what the correct high-level mental model is, then test to see if it fits the low-level features.
* Bottom-Up Processes:
  + Gestalt Grouping Principles:
    - Proximity
    - Similarity
    - Common Fate (moving in the same way)
    - Good Continuation (lie along a smooth curve)
    - Closure (can form a closed boundary)
    - Symmetry (can form a symmetrical pattern)
  + Phi Phenomenon – Humans will perceive apparent motion from appropriate sequences of discrete images. Eg. flip book animation, television etc.
  + Judder – Perception of jerky motion due to insufficient frame rate. Mediated by basic motion interpolation at display end or by applying motion blur to original frames.
  + Stereopsis – Ability to perceive depth due to binocular vision. Each eye sees a slightly different image and the mind interprets the disparities between the two images and fuses them into a single 3D mental picture.
* Top-Down Processes:
  + Context is very important. Used as a prior conditioning to overcome ambiguity and noise in low-level features.
  + The human mind applies heavy context conditioning even on low-level perception.
* Visual Reading – In English, 26 visual patterns in constrained sequences form meaningful words & sentences. Due to a strong use of context, legibility & errors may not matter.

# Sound:

* Series of cyclical air (or other medium) pressure changes.
* Sensitivity of Human Ear – 20 Hz to 20 kHz. Upper limit decreases over time.
* Pitch – Perception of Sound Frequency
* Loudness – Perception of Sound Amplitude
* Timbre – Perception of Sound Quality
* Loudness is subjective, but the sound pressure level measure (in dB) is normally used. Every 10 dB roughly doubles the loudness. 0 dB is the threshold of hearing.
* Sound Localization:
  + Lateral Plane (Left-Right):
    - Binaural (using 2 ears)
    - Low Frequencies: loudness difference between ears
    - High Frequencies: phase/envelope time-shift between ears
  + Sagittal Plane (Top-Down):
    - Monaural (individual ear)
    - The folds in the pinna create a frequency notch filter and when sound comes from different directions, different frequencies are suppressed.
* Sound Source Recognition – Humans have the ability to recognize environmental sounds, identity of a speaker by voice & music.
* Speech Perception – Humans segment speech audio stream into phonemes and syllables, which are grouped into words & sentences.
  + McGurk Effect – Visual cues can change our perception of speech.

# Other Senses:

* Smell & taste are detected by various chemoreceptor cells in our nasal cavity & taste buds.
* Sense of touch is experienced through different types of sensory mechanoreceptors – pressure, tension/stretching, vibrations at different frequencies (for sensing textures).
* Temperature is sensed through thermoreceptors.
* Pain is sensed by different receptor types throughout the body.
* Balance and acceleration is sensed through the vestibular system in the inner ear.
* Proprioception or the sense of one’s body position is achieved through various combinations of sensory input, including balance and muscle stretch.

# Human Attention:

* Humans have limited mental resources. Attention is the priority channeling of these resources to specific tasks.
* Two Forms of Attention Control:
  + Bottom-up: Stimuli-driven attention grabbing
  + Top-down: Goal-driven focus of attention
* Bottom-Up Attention Control:
  + Pre-attentive processing in the brain determines what stimuli is relevant to be raised to the conscious mind. Attention is drawn to changes and outliers in the stimuli subconsciously, quickly and with low effort.
  + For visual features, it depends on the type of features, how much variation there is in the common features & how different the outlier feature is.
  + Good designs need to incorporate visual features where important functions/ information must stand out pre-attentively. However, the user should not be overwhelmed with unnecessary variation.
* Top-Down Attention Control:
  + Requires conscious effort and the cost of the effort is felt. Focused subtasks must be carried out sequentially.
  + The need for top-down attention must be minimized for secondary tasks in UI design, such as navigating long menus.
  + During top-down attention focus, other bottom-up attention mechanisms will be diminished. Also known as selective attention.

# Higher Level Cognition & Affect:

* Memory – Sensory Memory, Short-Term Memory & Long-Term Memory:
  + Sensory Memory is a very short-term memory buffer at a sensory level.
    - There are different sensory memories for sight (iconic), hearing (echoic) & touch (haptic).
  + Short-Term Memory is used as working/scratchpad memory. It can be quickly formed and accessed but is also quickly lost.
    - Humans can remember 7 ± 2 chunks of information. A chunk of information refers loosely to a cluster of items.
    - Spatial Chunking: Easier to remember numbers in chunks instead of long sequences.
    - Familiar Context: Easier to remember things that have a familiar context.
  + Long-Term Memory is slow to form and access but will last the longest.
    - Research is unclear whether forgetting is a loss of memory or loss of index.
    - Declarative Memory: Relates to facts, knowledge & experiences. What.
      * Episodic Memory: Serial memory of events & experiences.
      * Semantic Memory: Structured memory of concepts, attributes, inter-concept relationships & conditional rules.
    - Procedural Memory: Relates to procedures & skills. How.
    - Long-term memorization is done through repetitive practice. Depends on total time, distribution of practice & familiar context. Mnemonics help.
      * Good UI designs will aid memory by providing familiar context or incorporating mnemonics.
* Reasoning:
  + Deductive Reasoning: Reasoning by logic. Known Rule → Observe Cause → Deduce Effect.
  + Inductive Reasoning: Create general rules or facts based on observations. Observations → Infer Rule.
  + Abductive Reasoning: Guess cause based on effect, i.e. reverse lookup rule. Known Rule → Observe Effect → Abduce Cause.
  + Analogical Mapping: Create a higher-level mapping rule from pairwise observations.
* Problem Solving:
  + Problem solving is how we carry out a complex task without direct instructions.
  + User uses *operators* to go from an *initial state* to a *goal state*, with many possible *intermediate states*.
  + Learning the Operators:
    - Prior Known (user manual, instructions etc.)
    - Trial & Error
    - Inductive Reasoning (same operator in other states)
    - Analogical Mapping (predicting the functions of new operators based on old ones)
  + Ways of Finding the Solution:
    - Random or Exhaustive Exploration of Different Operator Sequences
    - Heuristics (rule-of-thumb strategies) – choose next operator that goes to an intermediate state closer to the goal state.
    - Planning – decompose the problem into a sequence of subgoals & change plan dynamically depending on whether subgoals turn out to be achievable.
* Skill Acquisition:
  + Ability to problem solve in a specific domain becomes better with time & practice.
  + Novices learn simple, general purpose rules → Intermediate learners start to compile this knowledge into domain-specific composite rules through proceduralization & composition → Learners become experts as composite rules become more tuned for performance and selection of such rules become faster.
* Mental Models:
  + A mental model is a user’s idea of how a particular device or software works or behaves. UIs should respond in a manner that fits a user’s mental model to prevent gulfs.
  + Three different levels of mental models:
    - Physical Stance – Concerned with physical level of detail.
    - Design Stance – Concerned with engineering/design level of detail.
    - Intentional Stance – Concerned with behavioral level of detail.
* Affect / Emotions:
  + Short duration, lasting seconds to minutes.
  + Positive, Neutral or Negative.
  + Each emotion has distinct physiological responses.
* Personality Traits:
  + Permanent, long-term attributes.
  + Determining the personas of target users is an important aspect of UI design.

# Action & Behavior

* Motor Coordination – A physical action requires activation of multiple muscles, which have to be synchronously and adaptively controlled.
* Movement Modeling – Useful to have models to predict how quickly and efficiently users will be able to use a particular interface design.
  + Fitts’ Law:
    - = Movement Time
    - = Distance Needed to Move
    - = Target Width
    - = Start/Stop Time Constant (Device Dependent)
    - = Inherent Speed Constant (Device Dependent)
* Intentional Communication – Linguistic (Oral Speech, Written Text, Sign Language), Iconic (Sketches, Emoticons, Illustrations, Visual Signs, Placement of Objects) & Gestural.
* Non-Intentional Communication – Body Language (Head Pose, Eye Gaze, Facial Expression) & Vocal Paralanguage (Intonation, Pitch, Loudness).