Human Factors

029511-1
2013년 가을학기
10/03/2013
박경신

Human

- Input & output
  - Senses and effectors
- Memory
  - Sensory memory
  - Short-term memory (working memory)
  - Long-term memory (LTM)
- Processing
  - Problem solving
  - Learning, …

Human Input-Output Channels

- Input channels
  - Sight (Visual)
  - Hearing (Auditory)
  - Touch (Tactile, Haptic)
  - Smell (Olfactory)
  - Taste (Gustatory)
- Output channels
  - Movement (Voice)
  - …
- When you type…
  - Input : touch, hearing, sight
  - Output : movement of fingers

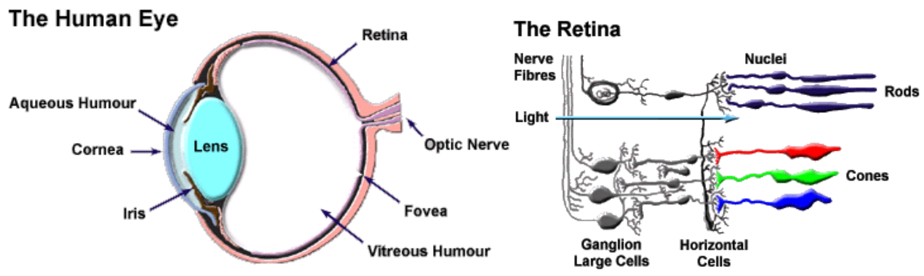
Vision

- Vision is one of the most studies subjects in HCI because designers should know …
  - What can be seen by users
  - What a user can see better
  - What can attract user's attention
- Two stages in vision
  - Physical reception of stimulus
  - Processing and interpretation of stimulus
  - There is no clear boundary between the two

Visual Perception

- Visual perception is more than physical reception
- What you see is not the image on the retina
  - The eyes are constantly moving, but the world that you see stays stable
- The brain creates and maintains an image of the world
- The eyes provide continuous updates to the brain to keep the illusion vivid
  - The eyes are moving constantly in order to gather information and build a high-resolution image of the world

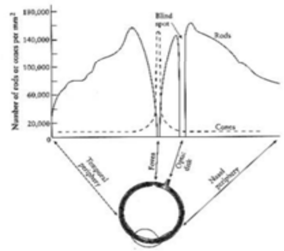
The Human Eye



The Human Eye

- Light is focused by the cornea and the lens onto the retina
- Light passing through the center of the cornea and the lens hits the fovea (or Macula)
- Iris permits the eye to adapt to varying light levels, controlling the amount of light entering the eye.
- Retina is optically receptive layer like a film in a camera
- Retina translate light into nerve signals.
- Retina has photoreceptors (rods & cones) and inter-neurons.

Rods and Cones



- Rods
  - **Dominate peripheral vision**
  - Operate at lower illumination levels
  - The most sensitive to light
  - At night where the cones cannot detect the light, the rods provide us with a **black and white** view of the world
  - The rods are also more sensitive to the blue end of the spectrum
- Cones
  - **Higher visual acuity**
  - Operate at higher illumination levels
  - Provide better spatial resolution and contrast sensitivity
  - Less sensitive to light
  - Provide **color vision** (currently believed there are 3 types of cones in human eye, one attuned to red, one to green and one to blue)

Ganglion Cells

- X-cells (P-ganglion cells)
  - Concentrated in the fovea
  - Responsible for detection of pattern & color
- Y-cells (M-ganglion cells)
  - Distributed widely in the retina
  - Responsible for detection of movement
  - Explains why the periphery vision is more sensitive to movement

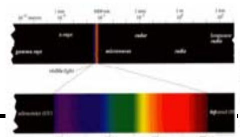
Brightness Perception

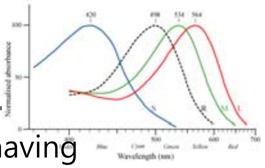
- The eye has a dynamic range of 7 orders of magnitude
- The eye is sensitive to ratios of intensities rather than to absolute difference. Brightness = Luminance^0.33
- The make something appear n times brighter the luminance must be increased by n^3
- Brightness
  - Visual system compensates for changes in brightness.
  - "Subjective" quantity
- Luminance
  - Determined by the light falling on an object, and the reflectivity of the object.
  - Physical quantity

Luminance

- Luminous Flux
  - Light energy per unit of time.
  - Measured in **lumens**
- Luminous Intensity
  - Luminous flux per solid angle emitted or reflected from a point.
  - Measured in lumens per steradian, or **candelas** (cd)
- Luminance
  - Luminous intensity per unit area projected in a given direction.
  - Measured in candelas per square meter

Color Perception





- We perceive electromagnetic energy having wavelengths in the range 400~700 nm as visible light.
  - There are three types of cones, referred to as **S, M, and L**. They are roughly equivalent to blue, green, and red sensors. Their peak sensitivities are located at 420 nm, 534 nm, 564 nm.
  - Color perception results from the simultaneous stimulation of the 3 cone types.
  - Color blindness results from a deficiency of one cone type.
- Most visual perceptual processes are driven by intensity not color.
  - Motion system is color blind, depth perception is color blind, object recognition is color blind
  - But uniquely colored objects are easy to find

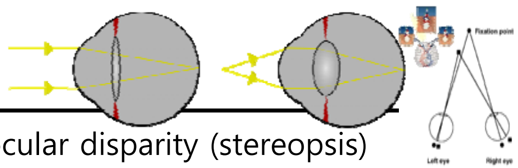
Temporal Resolution

- The real world doesn't flicker. The computer monitors do flicker because the image is constantly being refreshed.
- We perceive flickering if the image on the computer monitor isn't refreshed fast enough.
- Rate above which the human eye can no longer recognize discontinuous changes in brightness as a flicker. 31.25 Hz for most humans.
- Most people stop perceiving the flicker between 15 Hz (for dark image) and 50 Hz (for bright images).
  - Flicker is more noticeable when luminance is high
- Some people can perceive flicking even at 60 Hz for a bright display with a large field of view.
- Very large display may require up to 85 Hz.
  - The periphery vision is more sensitive to flicker
  - A larger display may suffer more from flicker

Visual Depth Cues
- Perceiving "depth" with one eye closed

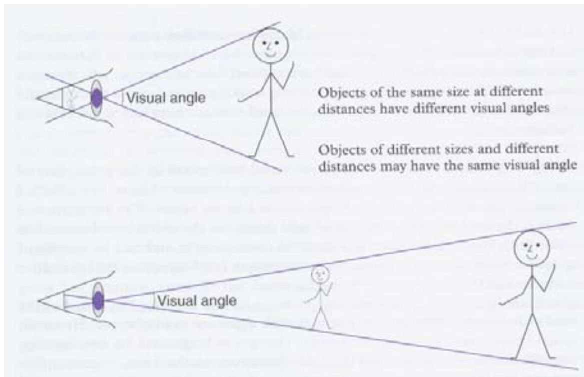
- Linear perspective
  - Objects get smaller the further away they are and parallel line converge in distance.
- Size of known objects
  - We expect certain object to be smaller than others.
- Detail (texture gradient)
  - Close objects appear in more detail, distant objects less.
- Occlusion (hidden surfaces)
  - An object that blocks another is assumed to be in the foreground.
- Lighting and Shadows
  - Closer objects are brighter, distant ones dimmer. Shadow is a form of occlusion.
- Relative motion (motion parallax due to head motion)
  - Objects further away seem to move more slowly than objects in the foreground.

Visual Depth Cues
- Using both eyes



- Binocular cues: binocular disparity (stereopsis)
  - This is the difference in the images projected onto the back of the eye (and then onto the visual cortex) because the eyes are separated horizontally by the interocular distance.
- Oculomotor cues: accommodation & convergence
  - Based on information from muscles in the eye
  - Accommodation (focus)
    - This is the muscle tension needed to ***change the focal length*** of the eye lens in order to focus at a particular depth.
  - Convergence
    - This is the muscle tension required to ***rotate each eye*** so that it is facing the focal point.
  - Accommodation and Convergence work together (when eyes converge to a certain distance, automatically accommodates and vice versa)

Perceiving Size: Visual Angle

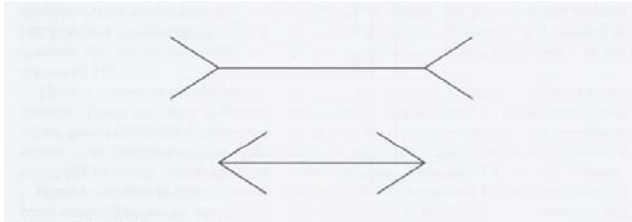


- Visual Angle
  - Objects of the same size at different distances have different visual angles
  - Objects of different sizes and different distances may have the same visual angle

Perceiving Size: More cues

- Law of size constancy
  - Take an object and move it further from you. Does it get smaller?
- Compensation by perception of depth
- Familiarity
- Occlusion by familiar objects

The Muller-Lyer Illusion



- Compensation by visual depth
  - Which segment looks shorter?
  - What do you think makes it appear shorter?

The Ponzo Illusion

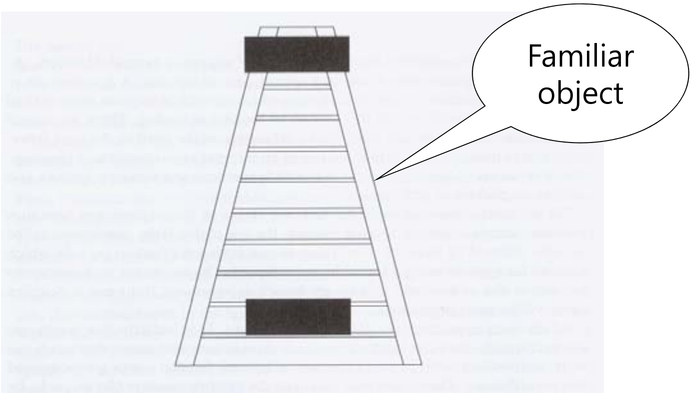


Figure 1.7 The Ponzo illusion

- Perceived size = distance x visual angle

Compensation & Constancy

- The image we perceive appears stable while the image on the retina is moving.
  - Visual processing compensates for the movement.
- Color and brightness of an object are perceived as constant.
  - An object under illumination at night may be perceived brighter than in the day time.
- Compensation can create an illusion.
  - The Muller-Lyer illusion
  - The Ponzo illusion
- Our *expectations* affect the way an object is perceived.
  - Help resolve ambiguity

Expectation (Context) Helps Interpretation

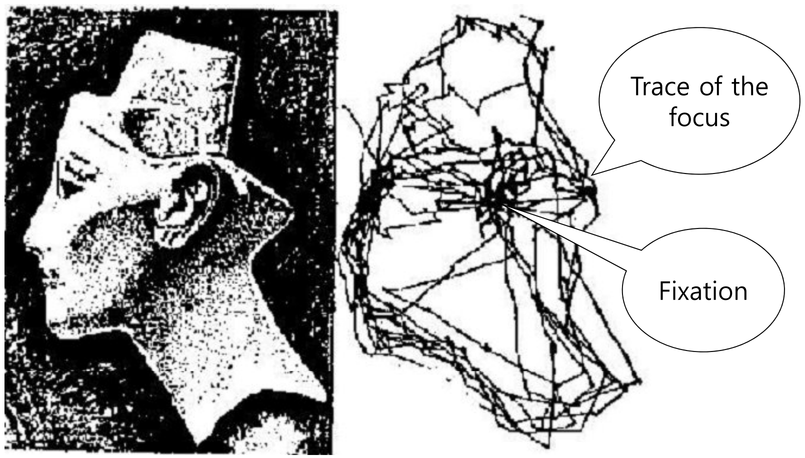
- An ambiguous shape?
  - Our expectation (context) helps the way an object is perceived

Reading

- Perception → decoding → synthetic & semantic analysis
- Saccades followed by fixations while reading
  - Perception occurs during fixation period.
  - Fixation accounts for 94% of the time.
  - Saccadic jumps occur before perception.
  - Saccadic Movement (Yarbus 1967)
- Familiar words are recognized by the shape.
  - All-cap words are more difficult to read.

O lny srmat poelpe can raed tihs. I cdnuolt blveiee taht I cluod aulaclty uesdnatnrd waht I was rdanieg. The phaonmneal pweor of the hmuan mnid, aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it deosn't mttaer in waht oredr the ltteers in a wrod are, t he olny iprmoatnt tihng is taht the frist and lsat ltteer be in the rgh it pclae. The rset can be a taotl mses and you can sitll raed it wouthit a porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe. Amzanig huh? yaeh and I awlyas tghuhot slpeling was ipmorantt! if you can raed tihs psas it on !!"

Saccadic Movement (Yarbus, 1967)



Reading

- Font size and line length affect legibility
  - 9-12 font size equally legible given proportional spacing between lines
  - Some rules of thumb for line length are 10-12 words per line or 40 chars per line
  - Lower case words and read faster than words in upper case
  - Individual letters and nonsense words UA1416 are read faster in upper case
- Positive contrast (light on dark) are preferred and show better performance
- When we read we focus on one word along with 4 chars to left and 15 chars to right

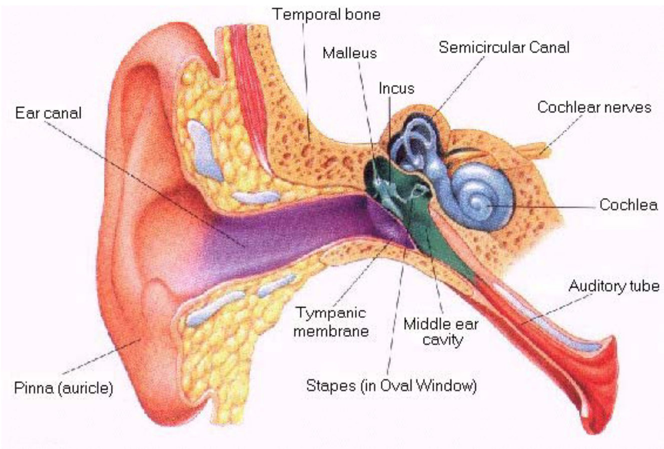
Reading

- You have several general choices of font styles to use
  - Sans-serif (e.g. Helvetica, Arial, Verdana, Tahoma) good for on-screen text (e.g. 72 dpi)
  - Serif (e.g. Times, Georgia) good for printed text (e.g. 150-300 dpi)
  - Mono-space good for certain occasions when you need exact alignment of the text
  - Fantasy/cute/brush strokes/cursive/dripping blood – just say no, unless you are creating a party invitation

Hearing

- By hearing, we can tell …
  - What sound is
  - Where it is coming from
    - Equally important for survival
    - But, how to tell if a sound is coming from before or behind you?
- Less effective than vision, but different!
  - Hearing is passive!
    - No need to turn head to focus on an object.
  - Sometimes, faster.

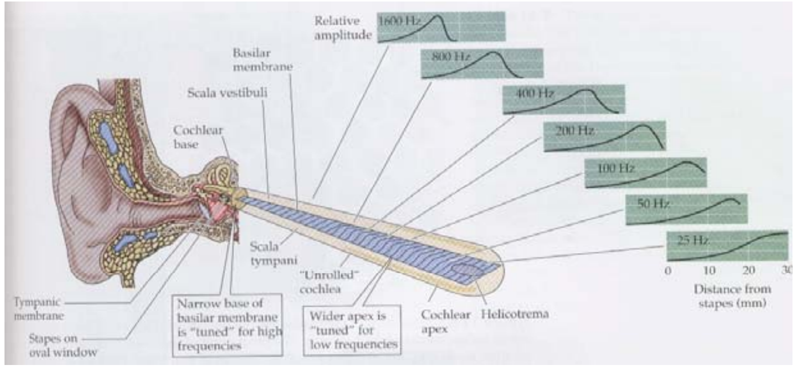
The Human Ear



The Human Ear

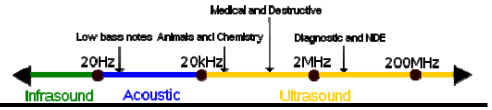
- Outer ear
  - Protects the middle ear
  - Amplify some sounds (spectral selectivity)
    - Help to determine the direction of a sound source.
- Middle ear
  - Ossicles (small bones)
  - Relays vibration of tympanic membrane to the inner ear
  - "**Impedance matching**" between air and liquid.
- Inner ear
  - Cilia (hair cells)
  - Transforms vibration of liquid to electrical signal
  - Similar to a spectrum analyzer (or a filter bank).

Cochlear



A spectrum analyzer

Processing Sound



- Three characteristics of sound
  - **Pitch** : the psychological perception of frequency
    - Lower pitch, more somber
  - **Loudness** : the power of sound
    - Low pitched sound tends to sound quieter
  - **Timbre** : the spectral distribution of sound
    - The tone quality or "**color**" of sound
    - Allows to distinguish two sounds of the same pitch and loudness
- Cocktail party effect
  - We can focus on a sound in noisy environment
  - Possibly because we have two ears
    - We can focus on a particular sound source in space.
    - This is just one of many possible explanations
- Audible frequency range
  - The human ear is limited to 20Hz-20kHz

Super Audio CD


General overview

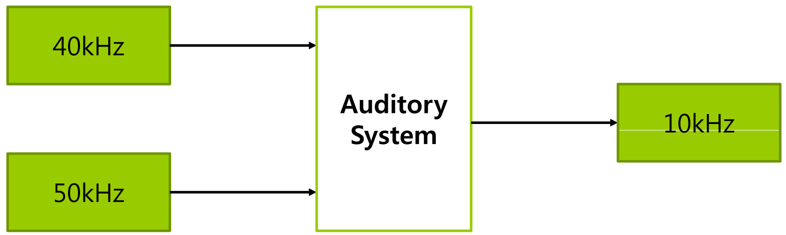
PHILIPS SONY

Super Audio CD is the latest, evolutionary music carrier that meets the highest demands of both the music industry and music lovers. It brings a breakthrough in the fidelity of music reproduction while still retaining full compatibility with the standard CD.

Based on the revolutionary Direct Stream Digital technology (DSD), it delivers superior sound quality in both stereo and multi channel. The DSD technology uses a sampling frequency of 2.8224 MHz, which is 64 times higher than that of CD. This enables a frequency response up to 100 kHz and a dynamic range of 120 dB across the entire audible range. The results is a close reproduction of the original analogue waveforms, leading to the playback of a warmer and more involving sound that captures the musical atmosphere of the live performance with outstanding realism.

- The music CD uses the sampling rate of 44kHz
- This means it totally discards sounds above 22kHz?

Beyond 20kHz



- Two ultrasounds that cannot be heard can be heard if the two are presented together.
- What is the required characteristic of the system?

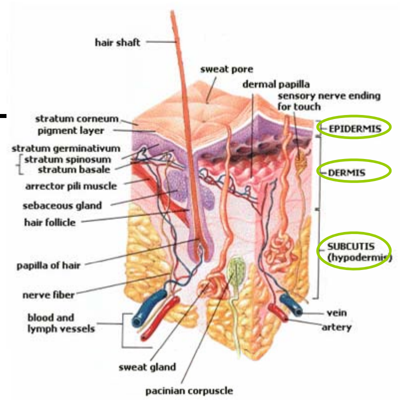
Haptic Perception

- Close your eyes and touch some object.
- Can you guess what it is?
- What kinds of information does your brain need to do that?
- **Haptic perception = tactile + kinesthesis**
  - A simplistic definition, but suffice to differentiate haptic from tactile sense.

Haptic Perception

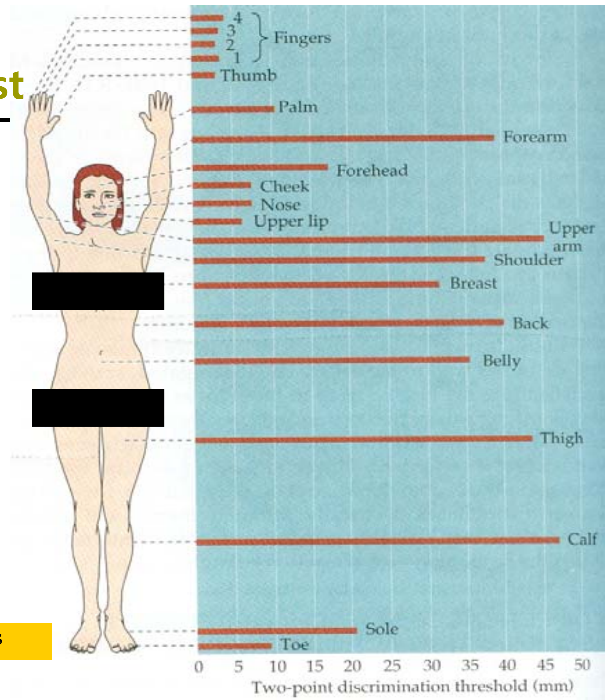
- Less important than sight or hearing?
- Primary feedback channel of motor control.
  - Imagine holding and lifting a glass without touch perception.
- Two different kinds
  - **Touch (tactile feedback)**
    - Receptors in the skin
    - Tells about the object that you touch
  - **Kinesthesis (proprioception/force feedback)**
    - Receptors in the muscles, tendons and joints
    - Tells the position of your body and limbs
    - Close your eyes. Can you tell where your hands are?

Touch (Tactile)



- Three types of receptors
  - **Thermoreceptors**
    - Heat and cold
  - **Nociceptors**
    - Intense pressure, heat and pain
  - **Mechanoreceptors**
    - Pressure
    - Possibly, most important to HCI
- Acuity of touch sense is not uniform
  - **Two-point threshold test**
    - Use two pencils and feel the tips on different parts of the body
  - Fingers have the highest acuity
    - The forearm is about 10 times less sensitive than fingers

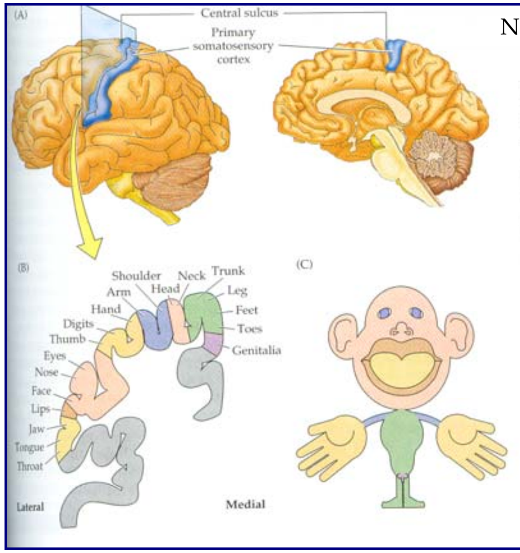
Two-Point Threshold Test



Neuronscience, Purves

http://www.ncbi.nlm.nih.gov/books/NBK11153/figure/A641/?report=objectonly

Somatosensory Mapping



Neuronscience, Purves

Figure 8.8 Somatotopic order in the human primary somatic sensory cortex. (A) Diagram showing the approximate region of the human cortex from which electrical activity is recorded following mechanosensory stimulation of different parts of the body. The patients in the study were undergoing neurosurgical procedures for which such mapping was required. Although modern imaging methods are now refining these classical data, the human somatotopic map first defined in the 1930s has remained generally valid. (B) Diagram along the plane in (A) showing the somatotopic representation of body parts from medial to lateral. (C) Cartoon of the homunculus constructed on the basis of such mapping. Note that the amount of somatic sensory cortex devoted to the hands and face is much larger than the relative amount of body surface in these regions. A similar disproportion is apparent in the primary motor cortex, for much the same reasons (see Chapter 16). (After Penfield et al., 1953; Corsi, 1991.)

Kinesthesis

- It's the sense that let you reach your nose in the dark!
- Receptors in the joints
  - Rapidly adapting receptors : sensitive to movement
  - Slowly adapting receptors : sensitive to movement of position
  - Position receptors : sensitive to position

Movement

- Movement time
  - Consider the whole information pathway until you press the brake when you notices a pedestrian.
  - **Visual perception → Processing in the central system →** Command to your foot (**motor control**)
  - Reaction time:
    - Visual perception – about 200 ms
    - Processing
    - Movement time – depends on age, fitness, physical condition, etc
- **Fitt's law**
  - The smaller a target, the more difficult to point it
  - T = a + b log (distance/size + 1)
  - Note this is just skilled behavior using **perceptual and motor skills**, not knowledge acquisition.

Fitt's Law

http://en.wikipedia.org/wiki/Fitts's_law

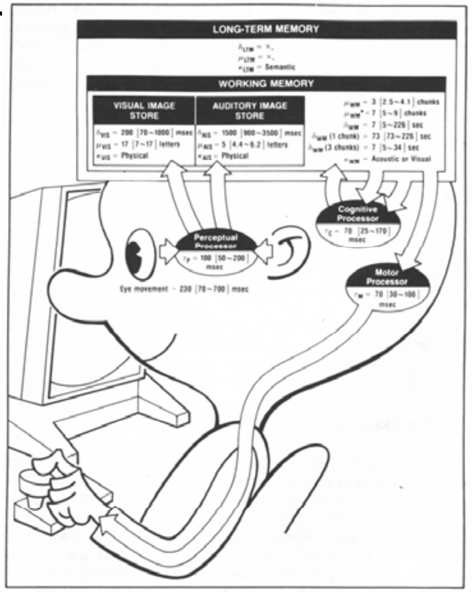
- Fitt's law (Paul Fitts, 1954)

$$T = a + b\,\log_2\left(1 + \frac{D}{W}\right)$$

T is the average time taken to complete the movement. (*movement time*)
a represents the start/stop time of the device (intercept)
b stands for the inherent speed of the device (slope)
D is the distance from the starting point to the center of the target
W is the width of the target measured along the axis of motion

  - Faster to hit a bigger target. Faster to hit a closer target
  - The smaller a target, the more difficult to point it
  - Predicts human speed in rapid aimed movement in one dimension
- Power law of practice
  - You will get better as you continue to perform as task, but the amount of improvement keeps decreasing … though fatigue will also be a factor.

Human Processor Model



- **The Psychology of Human-Computer Interaction by Stuart Card**
- Many experiments dating back to the 1960s to predict how quickly humans can detect and respond to a stimulus.
- E.g. User sees a sequence of random characters on the screen and is asked to press a button every time he sees an A.

Human Processor Model

- Human Processor Model by Card, Moran, Newell (1983)
  - Uses the **cognitive, perceptual** and **motor processors** along with the visual image, auditory image, working memory, and long term memory storages.

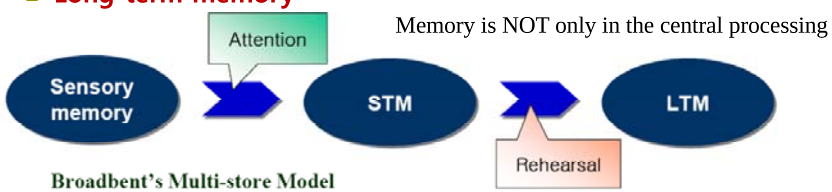
	Visual image storage	Auditory image storage	Short-term memory	Long-term memory
Capacity	17(7-17) letters	5(4.4-6.2) letters	3(2.5-4.1) chunks	∞
Decay	200(70-1000) msec	1500(900-3500) msec	7(5-226) sec	∞
Encode	Physical	Physical	Acoustic, Visual	Semantic
Processing cycle time	100(50-200)msec		70(30-100)msec	

Human Processor Model

- **The perceptual processor:**
  - Takes input from the eyes and ears and drops it into two temporary memories, the visual image store and the auditory image store.
  - As a computer hardware analogy, these memories are like frame buffers, storing a single frame of perception.
- **The cognitive processor:**
  - Operates on data from all the memories, including long-term memory, and puts its results back in the working memory.
- **The motor processor:**
  - Takes instructions from the working memory (which you might think of as RAM, although it's pretty small), and runs those instructions on the muscles.

Human Memory

- Human memory is in every level of human processing
  - **Encoding** - type of things stored
  - **Storage** - Sensory/Short-term/Long-term memory
  - **Retrieval**
  - **Forgetting** - Decay, Interference, Retrieval failure
- Three types of memory
  - **Sensory buffer (sensory memory)**
  - **Short-term memory (working memory)**
  - **Long-term memory**



Broadbent's Multi-store Model

Sensory Memory

- Examples
  - Iconic memory for visual stimuli (about 0.5 s)
  - Echoic memory for aural stimuli
  - Haptic memory for touch
- Some evidence
  - Iconic memory
    - Move your finger in front of you... You can see two fingers!
  - Echoic memory
    - A sound arrives at different times at two ears... but the brain can compare the two!
- ***Intentional attention*** passes information in sensory memory to short-term memory

Short-Term Memory

- Aka, working memory – a scratch pad for mental process
- When you read, you have to remember the foregoing words or sentences to understand the meaning
- Higher access time (~70ms), but faster decay (~200ms)

Short-Term Memory (2)

- Limited capacity
  - An average person can remember 7 digits.
  - It is more precise to say that **an average person can remember 7 entities.**
  - Grouping digits makes it possible to memorize more digits.
- Recency effect
  - **The last word is easier to recall.**
  - An extra activity between reading and recall invalidate this effect.
  - This suggests existence of separate short-term and long-term memory.

How Many Digits Can You Remember?

- Recall as many digits as you can.

- Recall as many digits as you can.

How Many Digits Can You Remember?

- What was the last digit?
- What was the first digit?

- Count backward from 10 to 1.
- What was the last digit?
- What was the first digit?
- Recall as many digits as you can.

Short-Term Memory (3)

- Short-term memories for different channels do not interfere.
- **Experiment by Baddeley**
  - A subject required to remember six-digit numbers is asked to answer questions on sentences... No interference

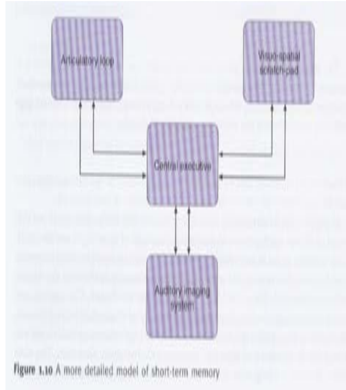


Figure 1.10 A more detailed model of short-term memory

Chunking & Closure

- Limited capacity of short-term memory
  → Subconscious desire to form a chunk
  - Ex1: 041-550-3469
  - Ex2: kpark2@hanmail.net
- When applied to a procedure...
  - Subconscious desire to flush memory when a task is done.
  - Ex1: ATM machine
    - Insert card → ... → Get card → "Get money"
  - Ex2: Vending machine
    - Insert coins → Press button → "Get coffee" → Collect change

7±2 Rule

- Possibly the most popular principle about the human memory in GUI design
- A unix command with fewer than 7 arguments
- A menu with fewer than 7 commands
- A dialog with fewer than 7 choices
- ...

Long-Term Memory

- For the long-term storage of information
- Differs from short-term memory in…
  - Capacity – huge, if not unlimited
  - Access time – a tenth of a second
  - Decay rate – much slower
- Two types of long-term memory
  - **Episodic memory**
    - Memory of event and experiences in a serial form
  - **Semantic memory**
    - Structured record of facts, concepts and skills that we have acquired
    - Number of different data structure proposed:
      - **Semantic Networks**
      - **Frames**
      - **Production Systems**

LTM: Semantic Network

- A **graph** where nodes are concepts and edges are relations.

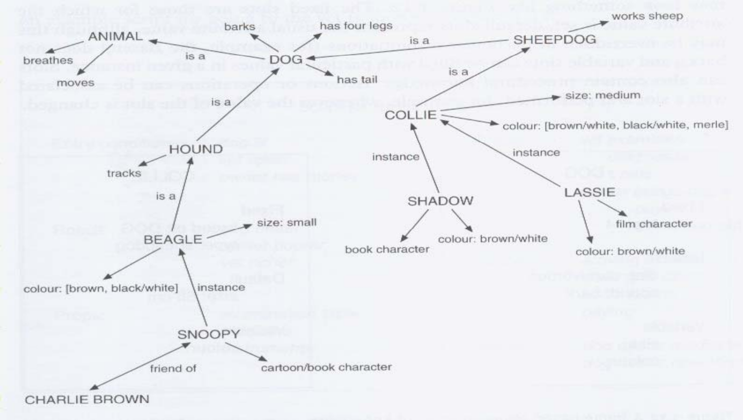


Figure 1.11 Long-term memory may store information in a semantic network

LTM: Semantic Network (2)

- Evidence of semantic network (**Collins and Quillian**)
  - Can a collie breathe?
  - Is a beagle a hound?
  - Does a hound track?
  - Which of the above questions takes longest to answer?
    - **Concepts semantically distant took longer to recall than concepts semantically close.**
- Shortcomings of semantic network
  - Has no predefined structure
  - Advantage: flexibility
  - Disadvantage: difficult to represent complex objects or events

LTM: Frames

- Frames have **slots** for default, fixed or variable information.
- Frames are instantiated when a value is assigned to a slot.
- Frames can be linked in a network to form a hierarchical structured knowledge.
- Allows the representation of more complex objects and events, composed of a number of items and activities.

Figure 1.12 A frame-based representation of knowledge

Semantic Network vs Frame

- What is the main difference?
  - Frames extend semantic networks to include structured, hierarchical information.
  - Make explicit the relative importance of each piece of information.
- Attributes of an instance is limited by the attributes of the super-class
- Imagine one of your English teachers in high school
  - His/Her major?
  - Kind?
  - Rich?
  - Bark?

LTM: Production Systems

- For representation of procedural knowledge
- **"Action-condition" rules** are stored in long-term memory.
- Information from short-term memory can trigger a rule.
- Examples:
  - IF dog is wagging tail
    THEN pat dog
  - IF dog is growling
    THEN run away

LTM: Processes

- Three main processes associated with the operation of memory:
  - **Storage or Remembering**
  - **Forgetting**
  - **Retrieving information**

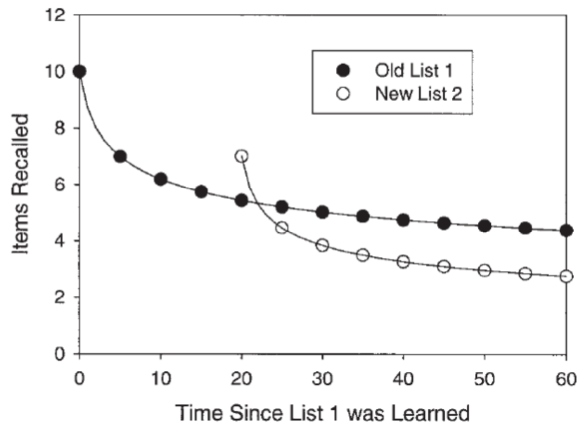
LTM: Remembering

- Total time hypothesis (Ebbinghaus)
  - The amount of learned is proportional to the amount of time spent learning.
- Distribution of practice effect (Baddeley)
  - Learning is more effective when it is distributed over time.
- Semantic content
  - Meaningful sentences are easier to remember – because one projects them on his/her semantic knowledge
  - Concrete words are easier to remember
  - A list of words representing concepts is more difficult to remember than a set of words representing objects
    - Faith, Age, Cold, Tenet, Quiet, Logic, Idea, Value, Past, Large
    - Boat, Tree, Cat, Child, Rug, Plate, Church, Gun, Flame, Head

LTM : Forgetting

- Memory **decays** logarithmically (Ebbinghaus)
  - Fast initially, but slowly later
  - **Jost's law** – If there are two equally strong memory traces at some point, the older one will persist longer.
- Theory of **interference**
  - **Retroactive interference** – A new memory trace tends to overwrite an existing, similar memory traces.
  - **Proactive interference** – A new memory trace is harder to remember if there is older but similar kinds of memory trace.
- Memory is selective
  - We tend to remember positive information better ("old good days").
  - More emotional events are easier to remember.

Jost's Second Law of Forgetting



LTM: Retrieval

- **Recall vs. Recognition**
  - Recall – Accessing memory items or attributes associated the current item in mind.
  - Recognition – Completion of a memory item from a partial clue
- Recall is possibly more complex process than recognition.
- If the person is allowed to categorize or structure the information, it makes retrieval easier.
- It is difficult to distinguish whether information decays or retrieval of information becomes harder.
- Visualization helps memorization and retrieval.

Embellishment

"The engines roared above the noise of the crowd. Even in the blistering heat people rose to their feet and waved their hands in excitement. The flag fell and they were off. Within seconds the car had pulled away from the pack and was careering round the bend at a desperate pace. Its wheels momentarily left the ground as it cornered. Coming down the straight the sun glinted on its shimmering paint. The driver gripped the wheel with fierce concentration. Sweat lay in fin drops on his brow…"

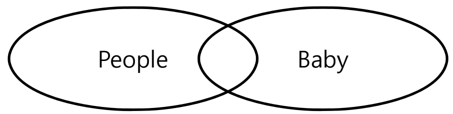
- What color is the car?
- People tend to visualize when they are told a story.
  - A side-effect of visualization is embellishment of additional information in order to complete the scene.

Thinking: Reasoning and Problem Solving

- We have considered how information is stored and retrieved. How do we process or make use of the information?
- **Reasoning** – inferring a conclusion from known facts.
  - **Deductive reasoning**
  - **Inductive reasoning**
  - **Abductive reasoning**
- **Problem solving** – finding a solution to an unfamiliar task.
  - **Gestalt theory**
  - **Problem space theory**
  - **Analogy in problem solving**

Reasoning

- Deductive reasoning
  - Derives a "logically necessary" conclusion from the given premises.
  - The conclusion may not correspond to our notion of truth.
    - If it is raining, then the ground is dry.
    - → It is raining, therefore, the ground is dry.
  - Are these valid deductions?
    - Some people are babies. Some babies cry.
    - → Some people cry.



Reasoning (2)

- Inductive reasoning
  - Generalization from some cases to all other cases.
  - It is not possible to prove a conclusion by induction.
  - The best thing we can do is to gather as much evidence as possible.
  - Though not reliable, **induction is the process that we use to learn facts and rules about our environment**.
- Abductive reasoning
  - Example:
    - Sam always drives too fast when he has been drinking.
    - → Sam is driving too fast, so he must have been drinking.
  - Although logically invalid, abductive reasoning is often used until evidence to the contrary is available.
  - Q: Is this useful?

Reasoning vs. Problem Solving

- Reasoning
  - Inferring new information from what is already known.
- Problem solving
  - Adapt the information we have to deal with a new situation.

Problem Solving: Gestalt Theory

- **Problem solving is both reproductive and productive.**
- Reproductive – solving by previous experiences
  - A person may fixate on the known aspects of a problem.
- Productive – solving by insight and restructuring of a problem.
  - Abundant examples, but how?
- **Maier's pendulum problem (1931)**
  - How to **tie two strings together** that are too far apart to hold at the same time given pliers, poles and extensions.
  - Reproductive or Productive?
  - Another barrier to problem solving is *functional fixedness*, whereby individuals fail to recognize that objects can be used for a purpose other than that they were designed for.

Problem Solving: Problem Space Theory

- **Newell and Simon (1972)** outlined their problem space theory of problem solving
  - People solve problems by searching in a problem space.
  - Problem space – Initial (current) state, goal state, and all possible states in between
  - Transition operators – The actions that people take to move from one state to another
  - Problem solving – Using transition operators to move from an initial state to a goal state
- Brute-force approach
  - Try all the possible operator sequences. Impractical due to the limited short-term memory and processing time.
- Applicable to a well-defined domains.
- In real world, finding knowledge for a problem and specifying a goal clearly are also part of problem solving.

Problem Solving: Analogy

- Analogical mapping
  - Mapping knowledge of a similar domain to a new problem.
- **Gick and Holyoak (1980)**
  - Problem – A doctor is treating a malignant tumor. In order to destroy it, he needs to blast it with high-intensity rays. However, these will also destroy the healthy tissue surrounding the tumor. If he lessens the rays' intensity, the tumor will remain. How does he destroy the tumor?
  - Analogy (Problem Solving) – A general is attacking a fortress. He can't send all his men in together as the roads are mined to explode if large numbers of men cross them. He therefore splits his men into small groups and sends them in on separate roads.
- Use of analogy is reminiscent of the Gestalt view of productive restructuring and insight.

Skill Acquisition

- **Skill is for familiar, repeated tasks** while problem solving is for unfamiliar, new tasks.
- The nature of skill is characterized by the behavior of experts.
- Better encoding of knowledge for a specific task.
  - Not all the problem states are equally probable.
  - Not all the state transition are equally important.
- **ACT* model (Anderson, 1983)**
  - A learner uses general-purpose rules.
  - A learner develops rules specific to a task. (proceduralization)
  - Rules are tuned for speed. (generalization)
- Think about driving

Errors and Mental Models

- Changes in the context of skilled behavior cause errors.
  - Driving a car in a country where a driver seat is on the right side.
  - Rules developed for the most likely situation can fail when applied to an unusual situation.
- Errors may occur when the actual operation differs from a mental model
  - Our mental models of a system is not always consistent because a mental model is often built from different experiences about the system.
- A good design should respect common conventions.

Individual Differences

- People do have many things in common, such as perceptual, mental, and physical functions.
- But, keep in mind that people have different preferences, tastes, as well as different perceptual, mental, and physical capabilities.
- A good design should adapt to individual differences, such as
  - Sex, physical capabilities, intellectual capabilities, …
  - Physical condition, mental condition, …
- Examples of bad designs from this view point
  - Unix command interface
  - Small buttons on a cell phone
  - …

Psychology and the Design of Interactive Systems

- Hasty generalization of results from psychological experiments is dangerous.
  - It is important to understand…
    - The context the experiments were carried out.
    - Who was involved in the experiments.
  - A carefully designed evaluation step should follow if one intend to apply a result from psychology to HCI design.
- Distilled principles are ready(?) for novice designers.
  - Guidelines for design
  - Models to support design
  - Techniques for evaluating design
- As-Jesus-Says designer… Ok, but if principles are in conflict?

References

- http://www.ncbi.nlm.nih.gov/books/NBK11153/
- http://www.uni.edu/~maclino/hs/documents/2point.pdf
- http://www.it.bton.ac.uk/staff/rng/teaching/notes/Memory.html
- http://cognitivepsychology.wikidot.com/cognition:problem-solving
- Dix, A., Finlay, J., Abowd, G., Beale, R. 1998 "Human-Computer Interaction" (Second Edition). Prentice Hall.