# Human Abilities

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## Agenda

- Human role in larger system
- Human capabilities
  - Senses
  - Information processing
  - Motor systems
- Project



## Human Role

- How is human viewed in HCI
  - What is human role?
- Different roles engender different frameworks





## Human Roles

- Human considered to be a…
- 1. Sensory processor
  - Experimental psych, sensory psych
    - e.g. Model-Human Processor (Card, Moran & Newell)
- 2. Interpreter/Predictor
  - Cognitive psych, AI
    - e.g. Distributed cognition (Hutchins)
- 3. Actor in environment
  - Activity theory, ethnography, ecol psych
    - e.g. Situated action (Suchman)
    - e.g. Activity theory (Vygotsky, Nardi)



## What Makes a System Usable

| *Human considered to be a...* | *Usability results when the system...* |
|---|---|
| Sensory processor | Fits within human limits |
| Interpreter/Predictor | Fits with knowledge |
| Actor in environment | Fits with task and social context |





## Evaluation Methods

| ***Human considered to be a...*** | ***Evaluation methods...*** |
|---|---|
| Sensory processor | Quantitative experiments |
| Interpreter/Predictor | Task analysis, cognitive walkthrough |
| Actor in environment | Ethnographic field work, participatory design |



## Two Views of Interaction

- Interaction *with*
  - Software system is a tool or machine
  - Interface is a usability-engineered membrane
  - Human-as-processor & -interpreter models
- Interaction *through*
  - Software is a medium used to interact with task objects or other people
  - Interface plays a role in social context
  - Human-as-interpreter & -actor models





## What are Humans Really Like?

- Models of behavior are only part of the information we need for successful design
- Need to know how users really are
- Abilities, needs, preferences



## Human Capabilities

- Why do we care? (better design!)
- Want to improve user performance


- Knowing the user <u>informs the design</u>
  - Senses
  - Information processing systems
  - Physical responding





## Overview

I. Senses
- A. Vision
- B. Hearing
- C. Touch
- D. Smell?

II. Information processing
- A. Perceptual
- B. Cognitive
  - 1. Memory
    - a. Short term
    - b. Medium term
    - c. Long term
  - 2. Processes
    - a. Selective attention
    - b. Learning
    - c. Problem solving
    - d. Language
- C. Motor system

III. Motor system



## I. Senses

- Sight, hearing, touch important for current HCI
  - smell, taste ???
- Abilities and limitations affect design



## Key concepts for Senses

Just noticeable difference (jnd)

How much of a change in stimulus is needed before can be sensed

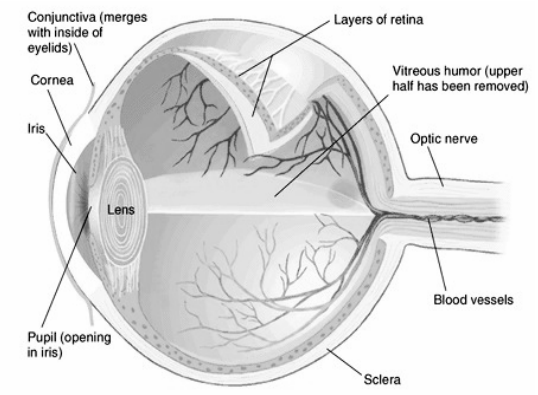
Tends to be logarithmic - Weber's Law

Magnitude of physical stimulus versus perceived magnitude

(Doubling number of photons does not double perceived intensity)

# Vision

- Visual System
  - Eye
  - Retina

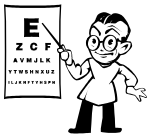



  - Neural pathway
    - ~ 80% of brain's operation



# Visual Abilities

- Sensitivity
  - luminance: $10^{-6}$~$10^{7}$ mL
- Acuity
  - detection, alignment, recognition (visual angle)
  - retinal position: fovea has best acuity
- Movement
  - tracking, reading, vibrations
- Note: Vision decreases with age
- **Implications (??)**
  - Font size & location depends on task
  - Much done by context & grouping



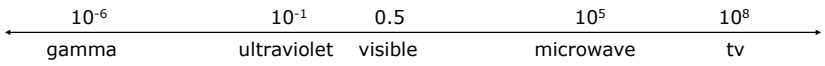

# Physiological Fundamentals

- Retina has
  - 6.5 M cones (color vision), mostly at fovea (1/3)°
  - About 150,000 cones per square millimeter
  - Fewer blue sensing cones than red and green at fovea
  - 100 M rods (night vision), spread over retina, none at fovea
- Adaptation
  - Switching between dark and light causes fatigue



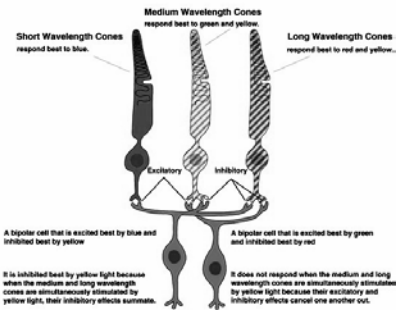
# Color

- Sensory response to electromagnetic radiation in the spectrum between wavelengths 0.4 - 0.7 micrometers




# Color Vision

- Color & the retina
  - 380 (blue) ~ 770nm (red)
  - Problems with cones or ganglion cells causes problems with color perception
  - (Not really "color blindness")
    - 8% males, 0.5% females




- Implications (??)
  - Avoid saturated colors
  - Color coding should be redundant when possible



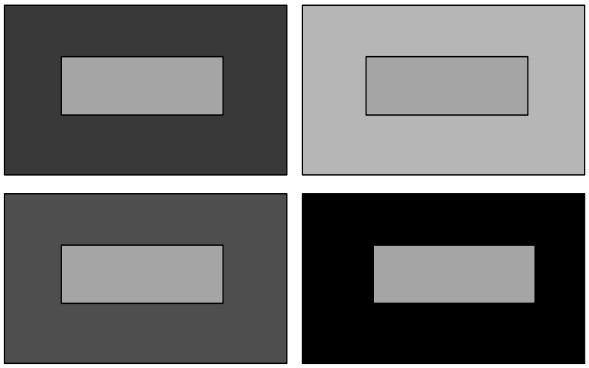
# Color/Intensity Discrimination

- The 9 hues most people can identify are:

| Color | Wavelength |
|---|---|
| Red | 629 |
| Red-Orange | 596 |
| Yellow-Orange | 582 |
| Green-Yellow | 571 |
| Yellow-Green | 538 |
| Green | 510 |
| Blue-Green | 491 |
| Blue | 481 |
| Violet-Blue | 460 |

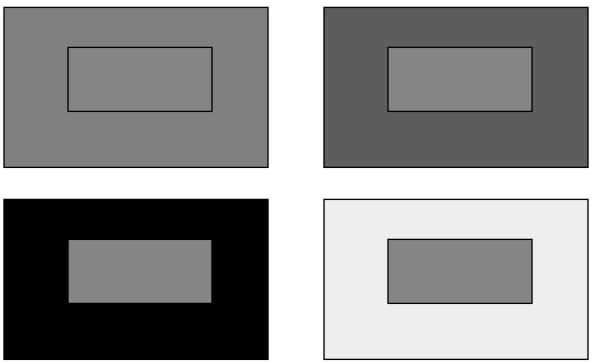
## Color Surround Effect

- Our perception of a color is affected by the surrounding color





## Color Surround



## Hearing

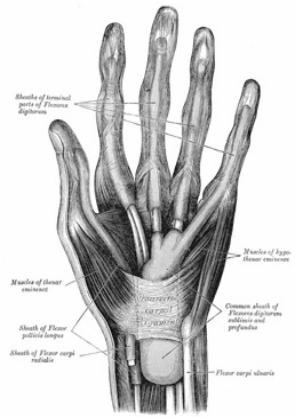
- Capabilities (best-case scenario)
  - pitch - frequency (20 - 20,000 Hz)
  - loudness - amplitude (30 - 100dB)
  - location (5° source & stream separation)
  - timbre - type of sound (lots of instruments)

- Often take for granted how good it is (disk whirring)
- Implications (??)



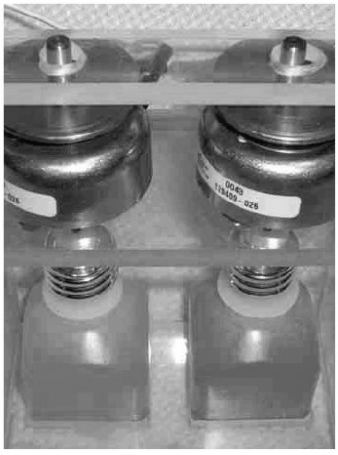
## Touch

- Three main sensations handled by different types of receptors:
  - Pressure (normal)
  - Intense pressure (heat/pain)
  - Temperature (hot/cold)
- Sensitivity, Dexterity, Flexibility, Speed
- Where important?
  - Mouse, Other I/O, VR, surgery



# Smell


Joseph Kaye, "Making scents: aromatic output for HCI" *ACM Interactions* Volume 10, Number 1 (2004), Pages 48-61



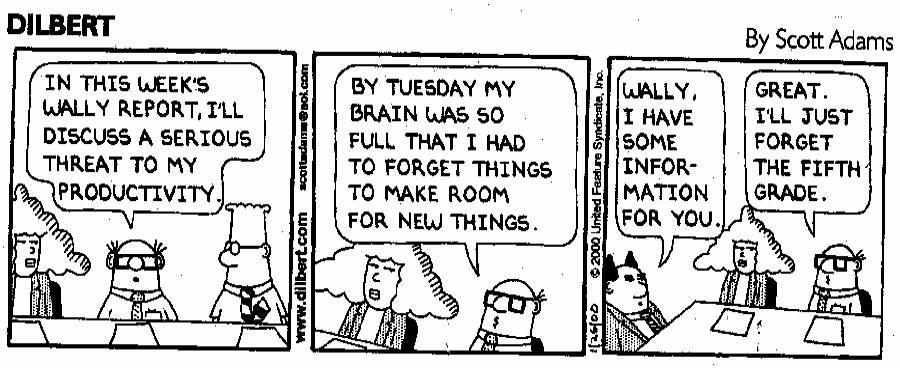
Solenoid-controlled scent bottles



# II. Information Processing

- How do people think?

# Typical Person :^)






# Information Processing

- Three major systems of human information processing:
  - Perceptual (read-scan)
  - Cognitive (think)
  - Motor system (respond)

# 1. Perceptual

- Memory structures
  - Sensory buffer - Holds fixed image of outside world long enough for some analysis
    (will come back to this)

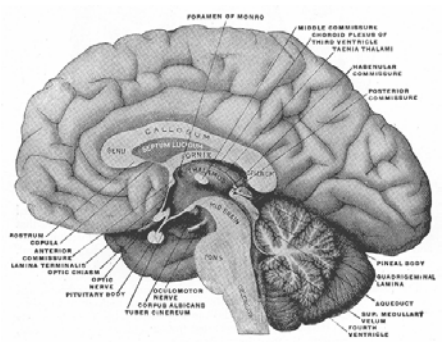
- Processes - Info goes to brain for more processing
  - e.g. Pattern recognition
  - Uses context & knowledge



# 2. Cognitive

- Cognitive model
  -

    How does it work?




## Memory

Chess

- Four "types"
  - **Perceptual "buffers"**
    - Brief impressions
  - **Short-term memory**
    - Conscious thought, calculations
  - **Intermediate**
    - Storing intermediate results, future plans
  - **Long-term**
    - Permanent, remember everything ever happened to us



## Perceptual Store

- Visual and auditory impressions
  - visuospatial sketchpad, phonological loop
- Very brief, but veridical representation of what was perceived
  - Details decay quickly (~.5 sec)
  - Rehearsal prevents decay
  - Another task prevents rehearsal

## Short-term memory

- Use "chunks": 4-5 units (not 7±2)
- Display format should match memory system used to perform task
- New info can interfere with old info
- Exercises
  - My name is John, I like …
  - Numbers



## Long-term Memory

- Seemingly permanent & unlimited


- Access is harder, slower
  - -> Activity helps (we have a cache)

## LT Memory Structure

- Episodic memory
  - Events & experiences in serial form
    - Helps us recall what occurred
- Semantic memory
  - Structured record of facts, concepts & skills
    - One theory says it's like a network
    - Another uses frames & scripts (like record structs)



## Memory Characteristics

- Things move from STM to LTM by rehearsal & practice and by use in context

Unclear if we ever really forget something

Lack of use

- We "forget" things due to decay and interference

Similar gets in way of old

Exercise

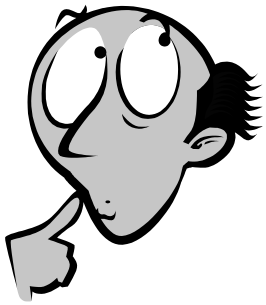
## Exercises

- Some fun...



## Processes

- Four main processes of cognitive system:
  - Selective Attention
  - Learning
  - Problem Solving
  - Language



## 1. Selective Attention

- We can focus on one particular thing
  - Cocktail party chit-chat
- Salient visual cues can facilitate s.a.
  - Examples? Boldface, blinking and beeping
- Visual or Auditory Streams form after a few seconds



## 2. Learning

- Two types:
  - Procedural – How to do something
  - Declarative – Facts about something
- Involves
  - Understanding concepts & rules
  - Memorization
  - Acquiring & automating motor skills
    - Bike riding, typing, tennis

## Learning

- Facilitated
  - By analogy
  - By structure & organization
  - If presented in incremental units
  - Repetition
- Hindered by
  - Previous knowledge (move from Mac to Windows)
- ---> Use user's previous knowledge in interface





## Observations

- Users focus on getting job done, not learning to effectively use system
- Users apply analogy even when it doesn't apply



## 3. Problem Solving

- Storage in LTM, then application
- Reasoning
  - Deductive- If A, then B
  - Inductive- Generalizing from previous cases to learn about new ones
  - Abductive- Reasons from a fact to the action or state that caused it



## Reasoning about a UI

- Deductive: If I want to delete something, I must first select it. *Facilitate by animating the disappearance of selected object*
- Inductive: I could make text bold by selecting it and then using the Bold command. Maybe I could italicize in the same way. *Facilitate by putting bold and italic commands together*
- Abductive:Timeout on the web browser if not connected. *Facilitate by telling the user why the timeout occurred*

## Observations

- People are more heuristic than algorithmic
  - Try a few quick shots rather than plan
    - Resources simply not available
- People often choose suboptimal strategies for low priority problems
- People learn better strategies with practice





## Implications

- Allow flexible shortcuts
  - Forcing plans will bore user
- Allow multiple ways of doing


- Provide active rather than passive help
  - Recognize dead ends and inefficient methods



## 4. Language

- Rule-based
  - How do you make plurals?
- Productive
  - We make up sentences
- Key-word and positional
  - Patterns
- Should systems have natural language interfaces?





## People

- Good
- Bad



## People

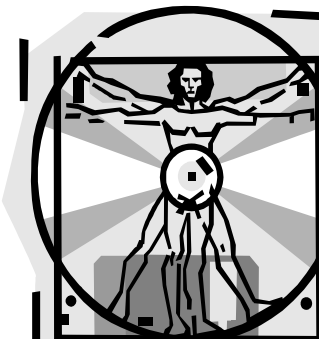
- Good
  - Infinite capacity LTM
  - LTM duration & complexity
  - High-learning capability
  - Powerful attention mechanism
  - Powerful pattern recognition
- Bad
  - Limited capacity STM
  - Limited duration STM
  - Unreliable access to LTM
  - Error-prone processing
  - Slow processing

Computer is opposite!
Allow one who does it best to do it!
(Function allocation)

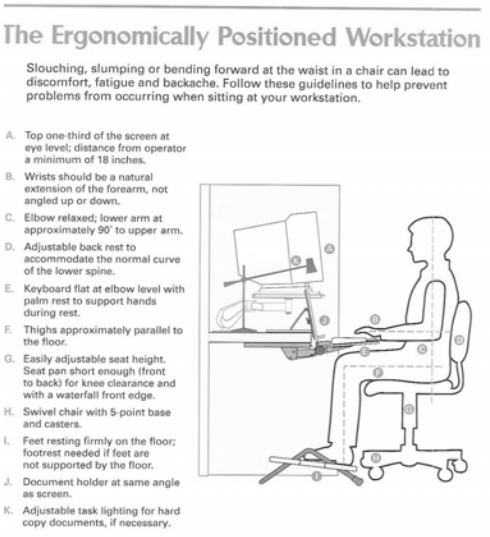


## III. Motor System

- Capabilities
  - Range of movement, reach, speed, strength, dexterity, accuracy
- Often cause of errors
  - Wrong button
  - Double-click vs. single click
- Principles
  - Feedback is important
  - Minimize eye movement



# Work Station Ergonomics – to Facilitate I/O



The Ergonomically Positioned Workstation

Slouching, slumping or bending forward at the waist in a chair can lead to discomfort, fatigue and backache. Follow these guidelines to help prevent problems from occurring when sitting at your workstation.

A. Top one-third of the screen at eye level; distance from operator a minimum of 18 inches.
B. Wrists should be a natural extension of the forearm, not angled up or down.
C. Elbow relaxed; lower arm at approximately 90° to upper arm.
D. Adjustable back rest to accommodate the normal curve of the lower spine.
E. Keyboard flat at elbow level with palm rest to support hands during rest.
F. Thighs approximately parallel to the floor.
G. Easily adjustable seat height. Seat pan short enough (front to back) for knee clearance and with a waterfall front edge.
H. Swivel chair with 5-point base and casters.
I. Feet resting firmly on the floor; footrest needed if feet are not supported by the floor.
J. Document holder at same angle as screen.
K. Adjustable task lighting for hard copy documents, if necessary.





# Recap

I. Senses
- A. Sight
- B. Sound
- C. Touch
- D. Smell?

II. Information processing
- A. Perceptual
- B. Cognitive
  - 1. Memory
    - a. Short term
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- C. Motor system

III. Motor

## Project

- Part 0 – Topics
- Part 1 - Understanding the problem
  - Work with client
  - Understand users, their tasks, environment
  - Informal evaluation of current interface, if it exists
  - Establish objectives, requirements for design
  - Implications of what you learn!
  - No design! No assumptions!
  - Read project description
- Make a nice top co-web page





## Upcoming

- Predictive Evaluation
- Understanding Users
- Task Analysis & Requirements Gathering