SENG 310: Human Computer Interaction

Lecture 6.
Human capabilities

Readings:
Hix et al: Chapter 1. The Human

User-centred design

- Iterative design using rapid prototyping
- Early focus on users and tasks
  - user analysis: who the users are
  - task analysis: what they need to do
  - involving users as evaluators and consultants

Continuous evaluation

  - Users are involved in every iteration
  - Every prototype is evaluated somehow

from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

User and task analysis

- First step of user-centred design
- The process of collecting information for the first design iteration
- User analysis: who is the user?
- Task analysis: what does the user need to do?

from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Know thy user

- Identify characteristics of target user population
  - Age, gender, ethnicity
  - Education
  - Physical abilities
  - General computer experience
  - Skills (typing? reading?)
  - Domain experience
  - Application experience
  - Work environment and other social context
  - Relationships ad communication patterns

from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Multiple classes of users

- *multi-layer design approach*
  - Novices use a subset of commands, actions, and objects
  - Can move up when they feel comfortable
- Most games
- Cell phones
  - Novices: phone calls easy to make
  - Experts: store #s, web, contact info
- Also involves manuals, help screens, error messages, tutorials, feedback

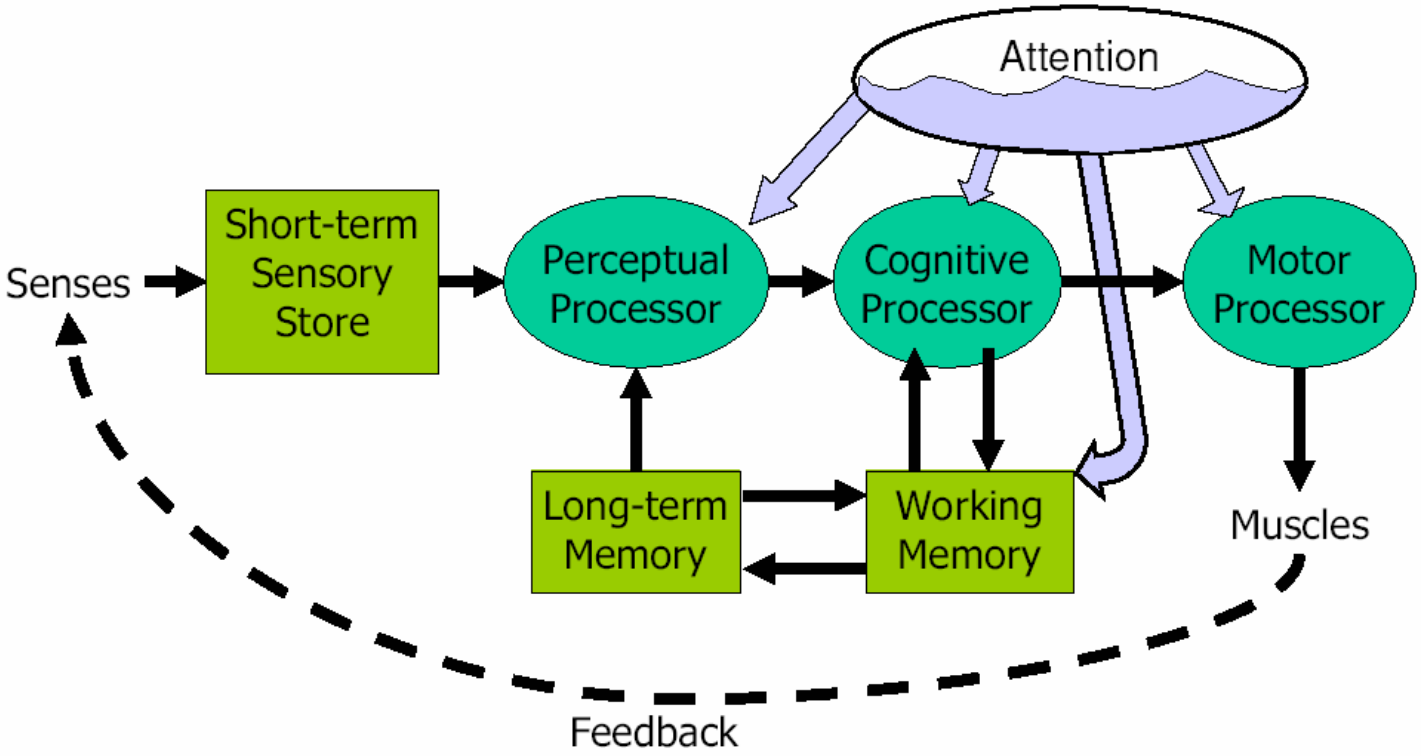
from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Human-centred design

- Human information processing
  - Perception
  - Cognition, decision making
  - Motor skills
  - Memory
  - Attention
  - Vision

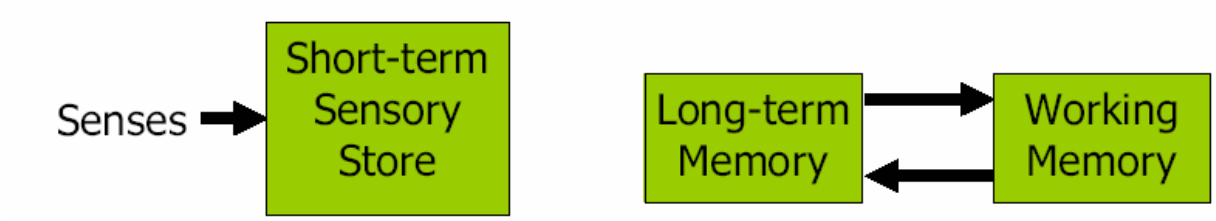
from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Human information processing



The Model Human Processor (Card, Moran, and Newell)

Memories



- Memory properties:
  - Encoding: type of things stored
  - Size: number of things stored
  - Decay time: how long memory lasts

Short term sensory store

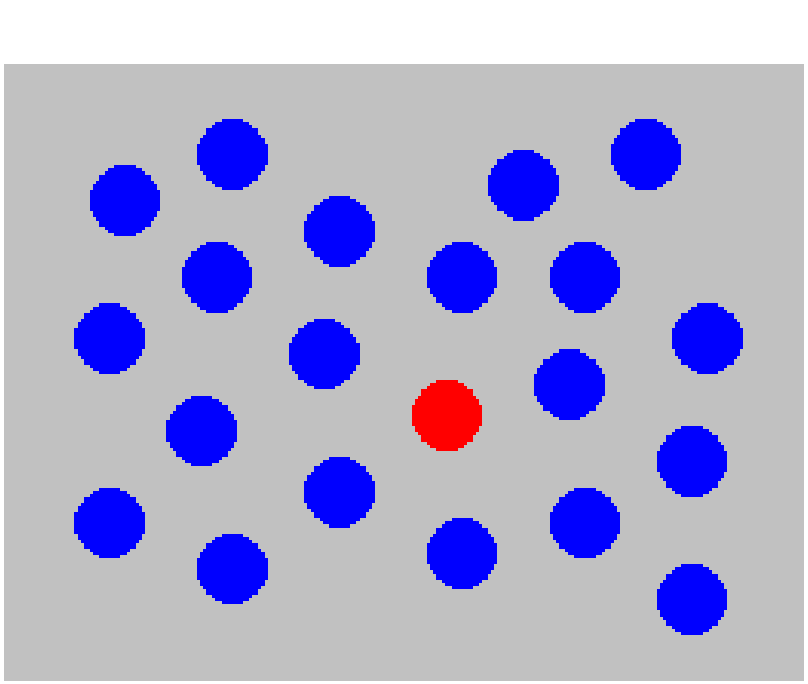
- also called sensory memory
- Visual information store (also called iconic memory)
  - Encodes physical features of the image (curvature, length, edges)
  - Size ~ 17 [7-17 letters]
  - Decay ~ 200 ms [70-1000 ms]
- Auditory information store (echoic memory)
  - Encodes physical sounds
  - Size ~ 5 [4.4 – 6.2 letters]
  - Decay ~ 1500 ms [900-3500 ms]

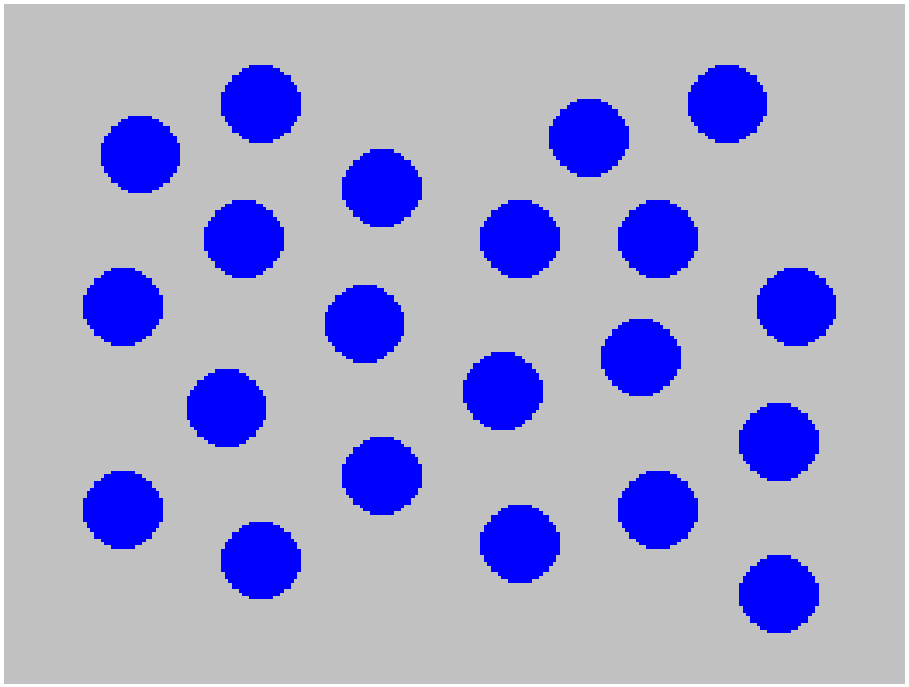
Sensory memory and preattention

- Sensory memory happens in the preattention stage where a stimulus is briefly analyzed to determine if it will receive additional processing.

PreAttention to color

Parallel visual search: all items in the display are processed simultaneously-- the search time is independent of the number of distractors

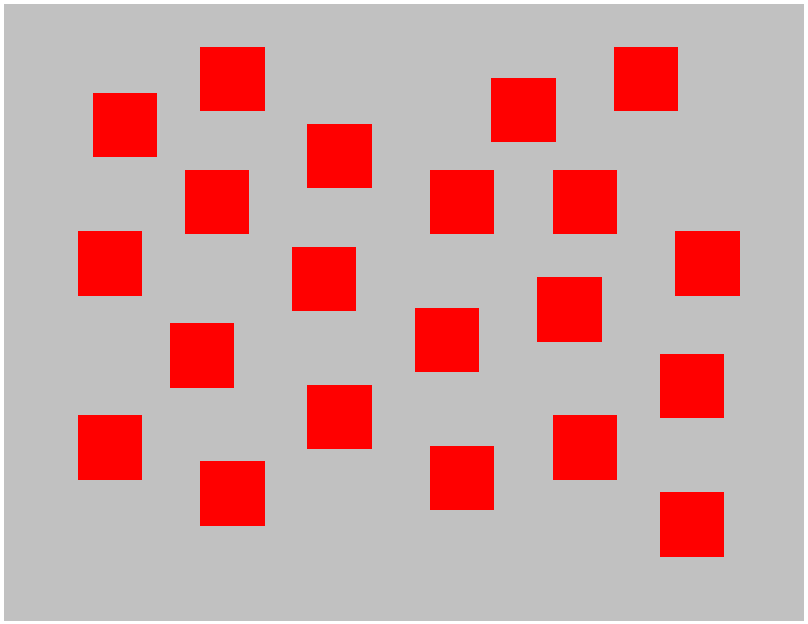


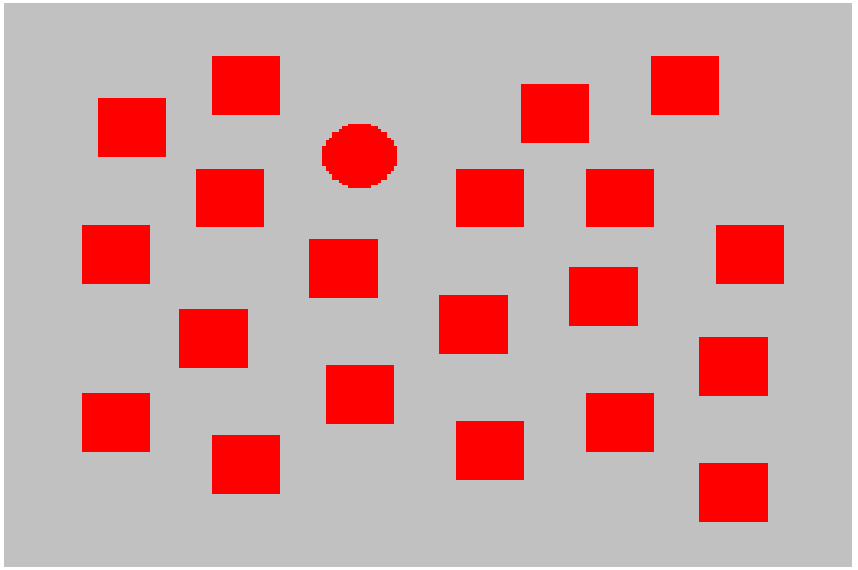


Viewer can rapidly and accurately determine whether the target (red circle) is present or absent.
Difference detected in color-- a single feature

PreAttention to form

Parallel visual search: all items in the display are processed simultaneously-- the search time is independent of the number of distractors





Viewer can rapidly and accurately determine whether the target (red circle) is present or absent. Difference detected in form (curvature)

Working memory

- Small capacity: 7±2”chunks”
- Fast decay (7 [5-226] seconds)
- Maintenance rehearsal fends off decay
- Interference causes faster decay

Design focus

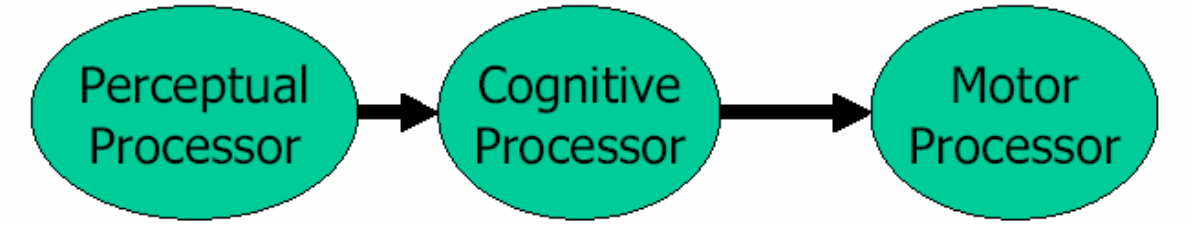
- Minimize use of short-term memory, memorization (George Miller’s “7 $\pm$ 2” **rule**)

Long-Term Memory

- Holds mass of knowledge
  - facts, procedures, skills, episodes
- Consists of a network of related chunks where edge in the network is an association
- Fast read, slow write
- Infinite capacity, but you may "forget" because:
  - cannot find effective retrieval cues
  - similar associations to other chunks interfere with retrieval of the target chunk

Processors

- Processors have a cycle time
  - T_p~ 100 ms [50-200 ms]
  - T_c ~ 70 ms [30-100 ms]
  - T_m ~ 70 ms [25-170 ms]



- Fastman, Slowman, Middleman

from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Perceptual fusion

- Perceptual fusion: limits of distinguishability of two different perceptual events
  - Temporal fusion (events happen in same temporal perceptual processing cycle)
  - Spatial fusion (e.g. sound / image come from same direction)
  - Unimodal fusion (e.g. images in two eyes fuse to create stereo vision)
  - Perceptual causality

Exercises

- Assume perceptual cycle time = 100ms
- If 20 clicks per second are played for 5 seconds, about how many clicks could a person hear?
- If 30 clicks per second are played for 5 seconds, about how many clicks could a person hear?

Exercises

- How many frames per second must a video be played to give illusion of motion?
- In a talking head video, how far off can the audio and video be before a person perceives the video as unsynchronized?
- In a driver's instrument panel, would a digital or spatial display be faster for gauging speed?

Perception

- Many paradigms for visual perception : bottom-up versus top-down
- Marr's theory of vision: strictly bottom-up, hierachical
- Bottom-up uses features of stimulus
- Top-down uses context
  - temporal, spatial
  - draws on long term memory

Evidence of top-down processing

- Visual illusions (Gregory)

(a) and (b) (black hat) show the front and side truly convex view; (d) (white hat) shows the inside of the mask; it appears convex although it is truly hollow; (c) is confusing as part of the hollow inside is seen as convex, combined with the truly convex face.

Top-down knowledge of faces is pitted against bottom-up visual information.

Chunking

- A single unit of information
  - a letter, number, graphic symbol, etc.
- Units glued together with associations
  - words and phone numbers

- A “chunk” represents a unit of perception and memory;
- Chunking depends on presentation and on past experience

from Dr. Rob Miller’s Lecture notes on UI Design and Implementation, MIT 2004.

What is attention?

- The human information processing system is limited in terms of allocation of resources to sensory and perceptual information
- The term **attention** is user to refer to this allocation of processing resources
- *"Everyone knows what attention is. It is the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. It implies withdrawal from some things in order to deal effectively with others" (William James, 1890)*

from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Attention and perception

- Spotlight metaphor
- Spotlight moves serially from one input channel to another
- Visual dominance: easier to attend to visual channels than auditory channels

from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Say the colour of these words aloud

Book

Pencil

Slide

Window

Car

Hat

Now do it again

Lessons learned

- Secondary characteristics of our displays (e.g. multiple dimensions of the stimulus, or context around the stimulus) must **reinforce** the message of the display, not **interfere** with it.

Cognitive processing

- The cognitive processor uses the long-term memory (LTM) and the working memory (WM)
- Executive system
  - solves problems, reasons, and make decisions
  - allocates attentional resources
  - schedules actions with motor system

Types of decision making

- Skill-based
- Rule-based
- Knowledge-based

Hick-Hyman Law of Choice Reaction Time

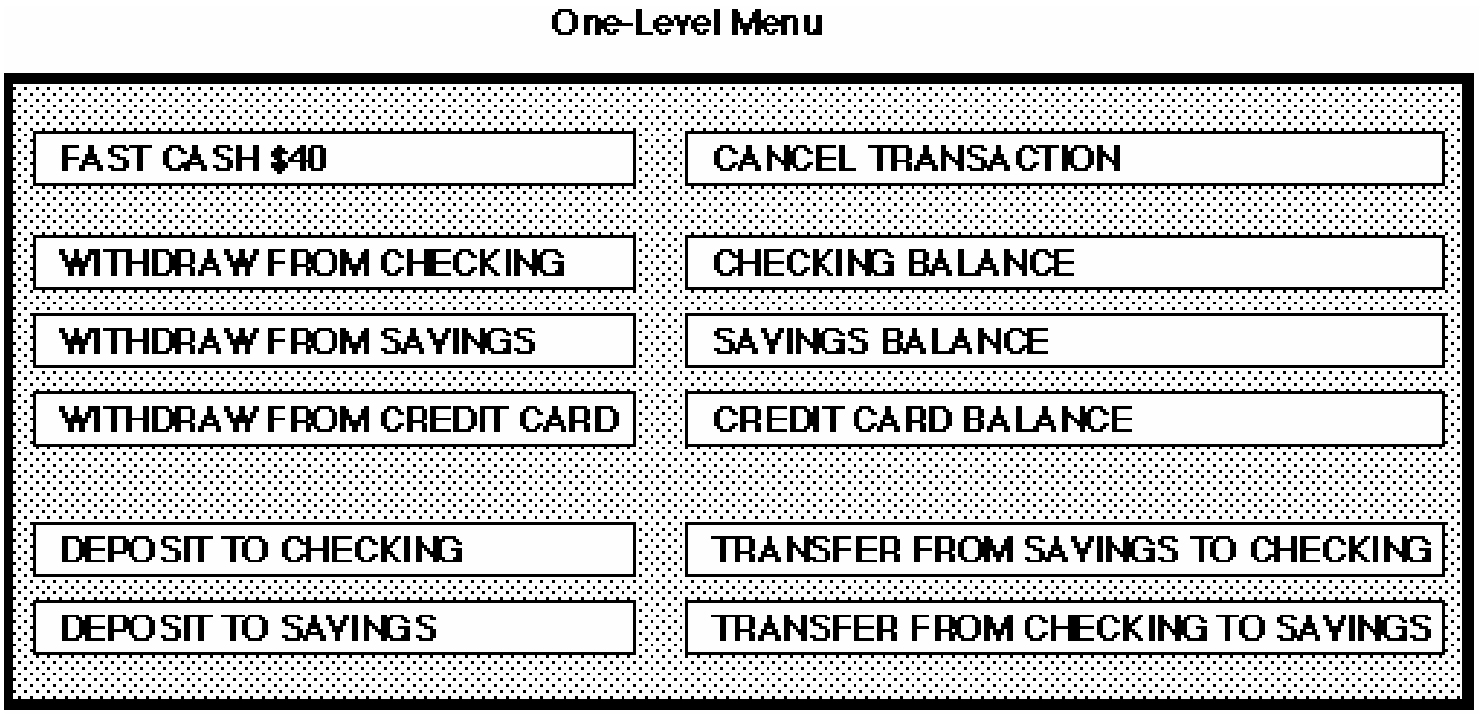
- Simple reaction time takes just one cycle of the human information processor $T_p + T_c + T_M$
- If the user must make a choice, the reaction time depends on the information content of the stimulus

$$RT = c + d \log_2 1/Pr(stimulus)$$

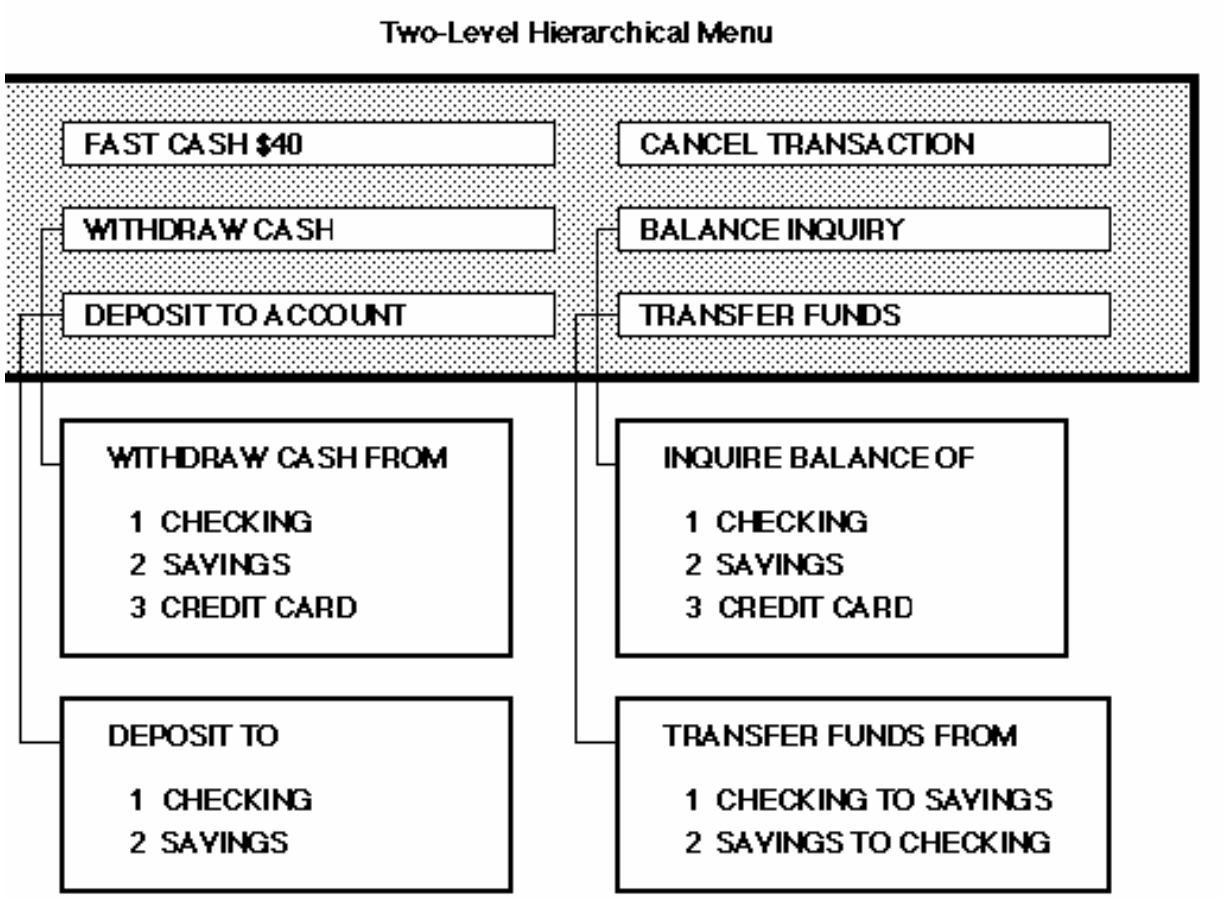
$$RT = c + d \log_2 N$$

from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Menu design: depth versus breadth trade-off



Menu design: depth versus breadth trade-off (cont'd)



Divided attention (multitasking)

- We'll use now the resource metaphor for attention
- Multitasking performance depends on:
  - Task structure (visual vs. auditory)
  - Encoding (spatial/graphical/sound vs words)
  - Mental Components: perceptual/cognitive vs motor
  - Difficulty: easy or well-practiced tasks are easier to share

from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Motor Processor

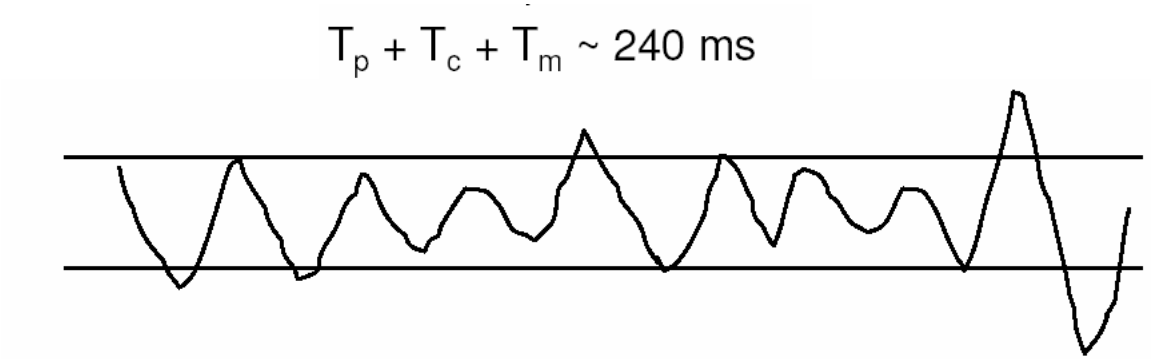
In open-loop control operation mode, it controls movements of body without feedback from the perceptual system

- movement composed of discrete micro-movements
- micro-movement lasts about 70ms
- cycle time of motor processor about 70ms

Adapted from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Motor Processor (cont'd)

- In closed-loop control operation mode, muscle movements (or their effect on the world) are perceived and compared with desired result
- The perceive-recognize-act cycle lasts



from Dr. Rob Miller's Lecture notes on UI Design and Implementation, MIT 2004.

Exercise #1

Compute the reaction time for a simple matching task

A user sits before a computer terminal. Whenever a symbol appears, s/he must press the space bar. What is the time between stimulus and response?

Exercise #2

Compute the reaction time for the symbol matching task

- Two symbols appear on the computer terminal. If the second symbol matches the first, the user presses “Y” and presses “N” otherwise. What is the time between the second signal and response?

Fitt's Law

a formal relationship that models speed/accuracy tradeoffs in *rapid*, *aimed* movement (not drawing or writing).

- $MT = a + b \log2(2A/W + c)$

- *MT* is the movement time
- *a* and *b* are empirically determined constants, that are device dependent. c is a constant of 0, 0.5 or 1
- *A* is the distance (or amplitude) of movement from start to target center
- *W* is the width of the target (accuracy)
- The term $\log2(2A/W + c)$ is called the index of difficulty (ID).

Fitts' Law: Physical interpretation

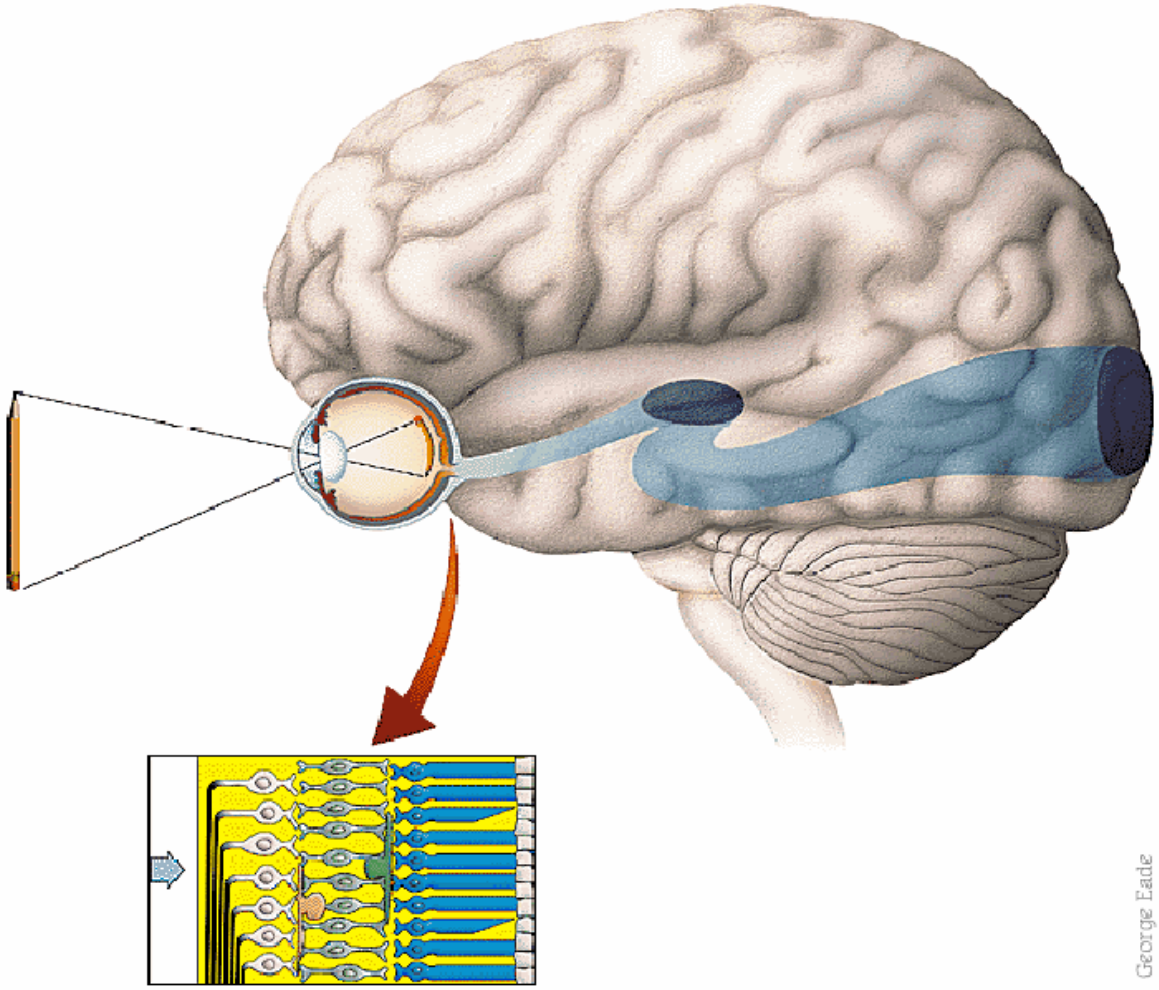
- Big targets at close distance are acquired faster than small targets at long range;
- ID provides a single combined measure of two main physical properties of movement tasks;
- ID increases by one unit for each doubling of amplitude and halving of width;

Applying Fitts' Law to interface design

- Things done more often should be assigned a larger button.
- Things done more often should be closer to the average position of the user's cursor. The amplitude (A) of a widget allows more control from interface designers compared to the width (W).
- The top, bottom, and sides of the screen are infinitely targetable because of the boundary created by the edges of the screen.

Applying Fitts' Law to interface design

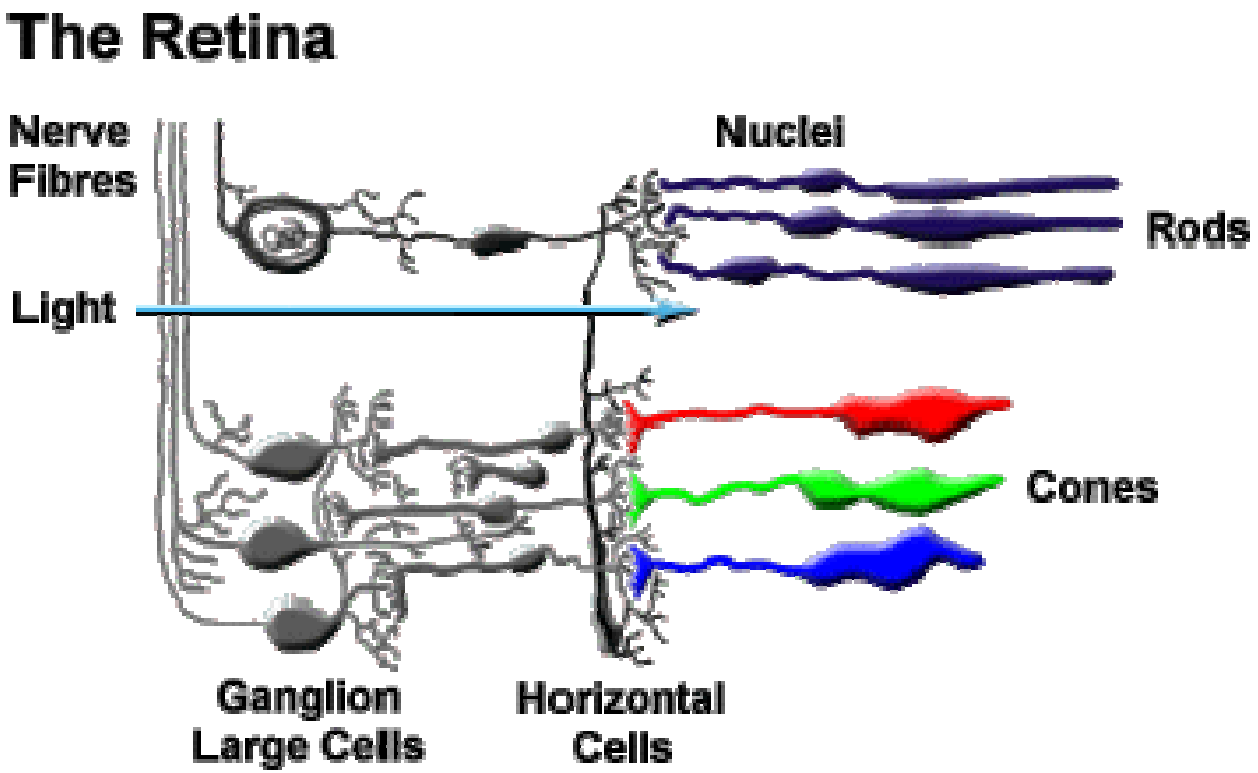
- Explain why pie menus are faster to use than linear popup menus.



Different photoreceptors in the retina: rods and cones

When excited, they produce nerve impulses which travel across the optical nerve

Sensors for colour perception in the human eye

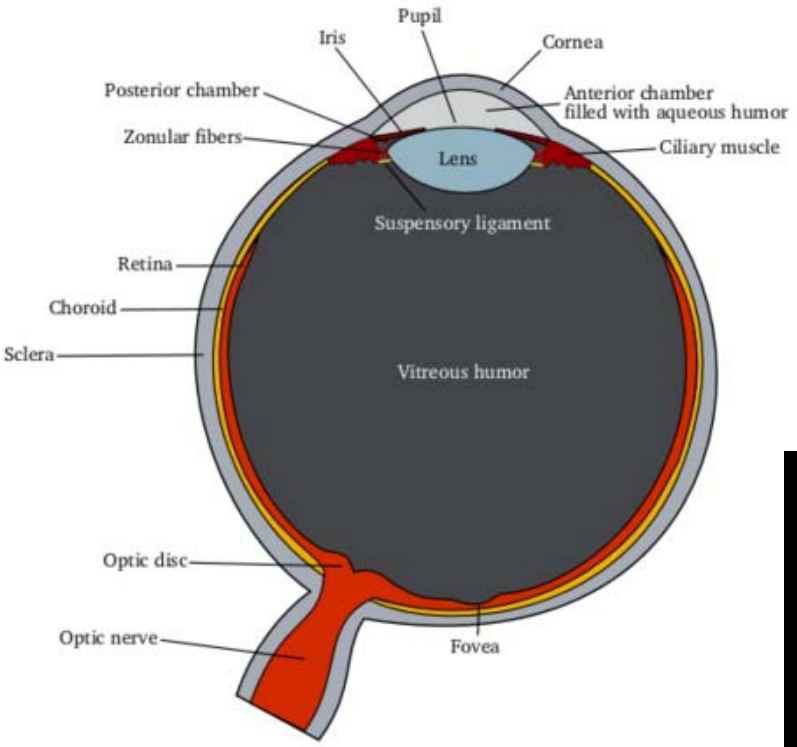


Three types of cones having the ability to sense three different (but overlapping) spectral regions.

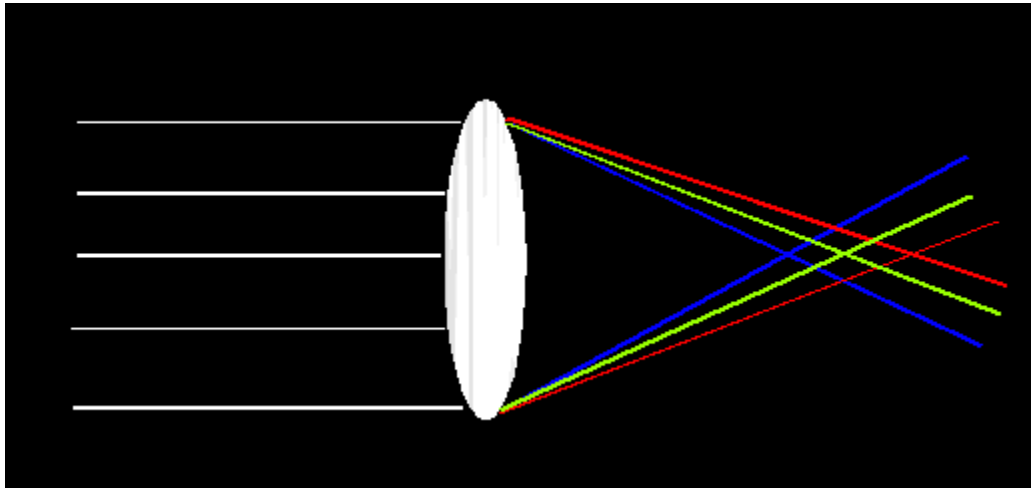
Using colour in interface design

- Colour vision does not simply detect the wavelength composition of light transmitted from the object;
- it analyses an object in relation to its background.
- Choose colours in context, not in isolation. Pastel colours (pale grey or blue) are best for **background.**

Using colour in interface design (cont'd)



- Be careful which colours you use together.
- Red and blue, for example, have very different wavelengths.
- The eye strains to provide sharp focus for both these saturated (pure) colours simultaneously.



initial scene

The chromatic aberration: a distinct purple border at the left and upper side and a less pronounced green border at the right and down side

Detail : chimney pot

From Paul van Walree, Chromatic aberrations.