# HCI BASICS

Lecture 1

# Agenda

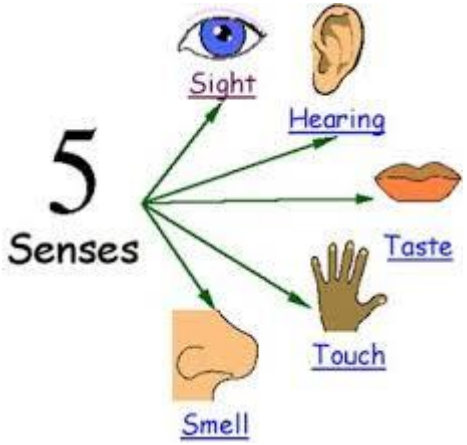
- The Human
- The Computer
- The Interaction

# THE HUMAN

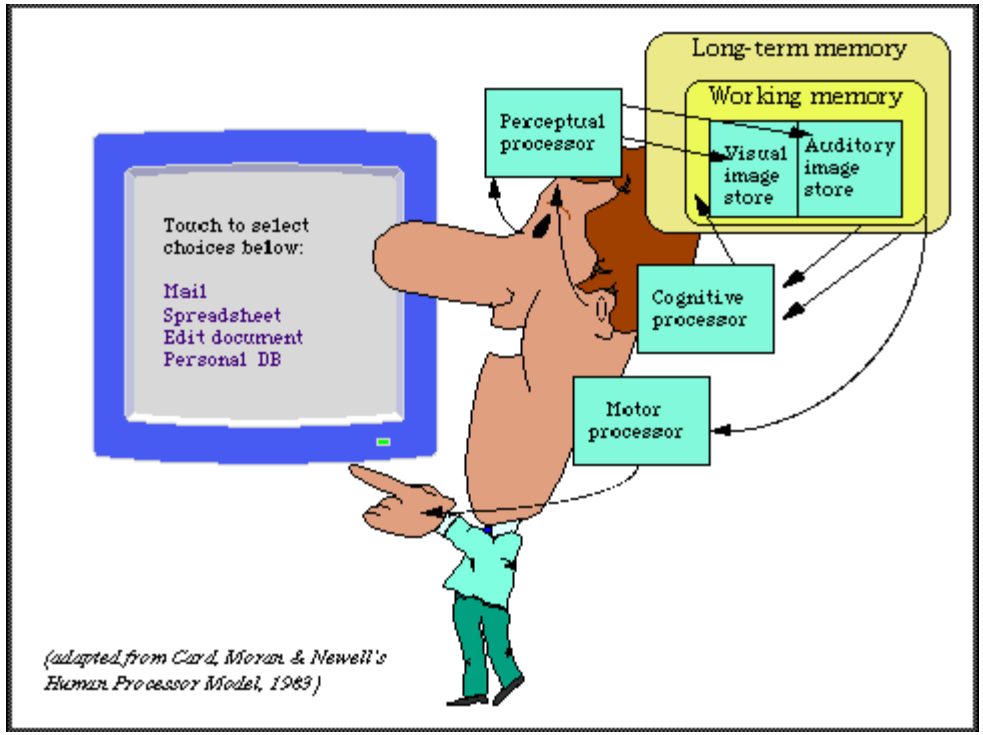
HCI Basics

# The Human

- Information i/o …
  - visual, auditory, haptic, movement
- Information stored in memory
  - sensory, short-term, long-term
- Information processed and applied
  - reasoning, problem solving, skill, error
- Emotion influences human capabilities
- Each person is different

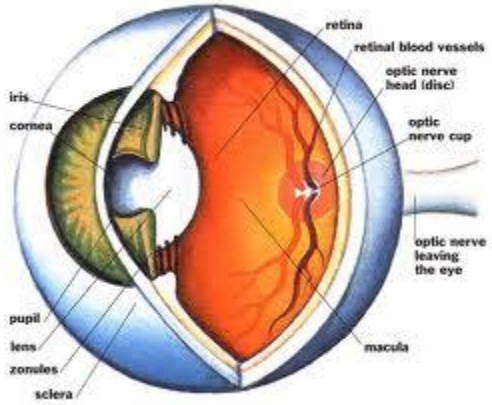


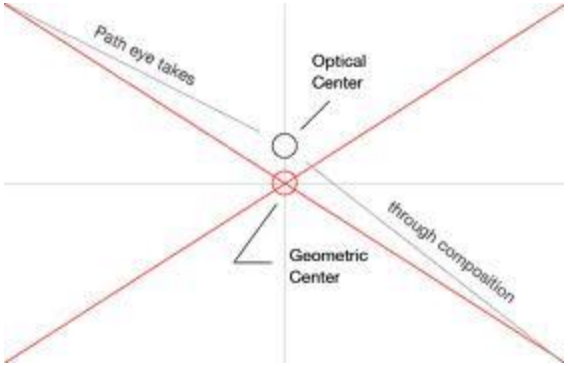

# Model Human Processor



# Vision

- Two stages in vision:
  - physical reception of stimulus
  - processing and interpretation of stimulus
- “Designing with blue”
- Optical center



# The Eye - physical reception

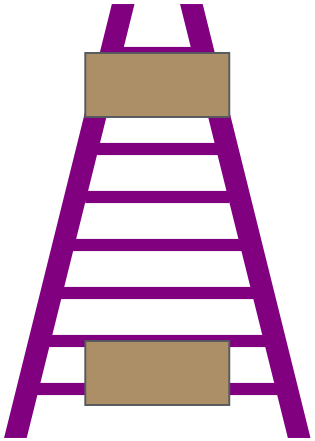
- mechanism for receiving light and transforming it into electrical energy
- light reflects from objects
- images are focused upside-down on retina
- retina contains rods for low light vision and cones for colour vision
- ganglion cells (brain!) detect pattern and movement

# Vision

# Vision - compensation

# Vision

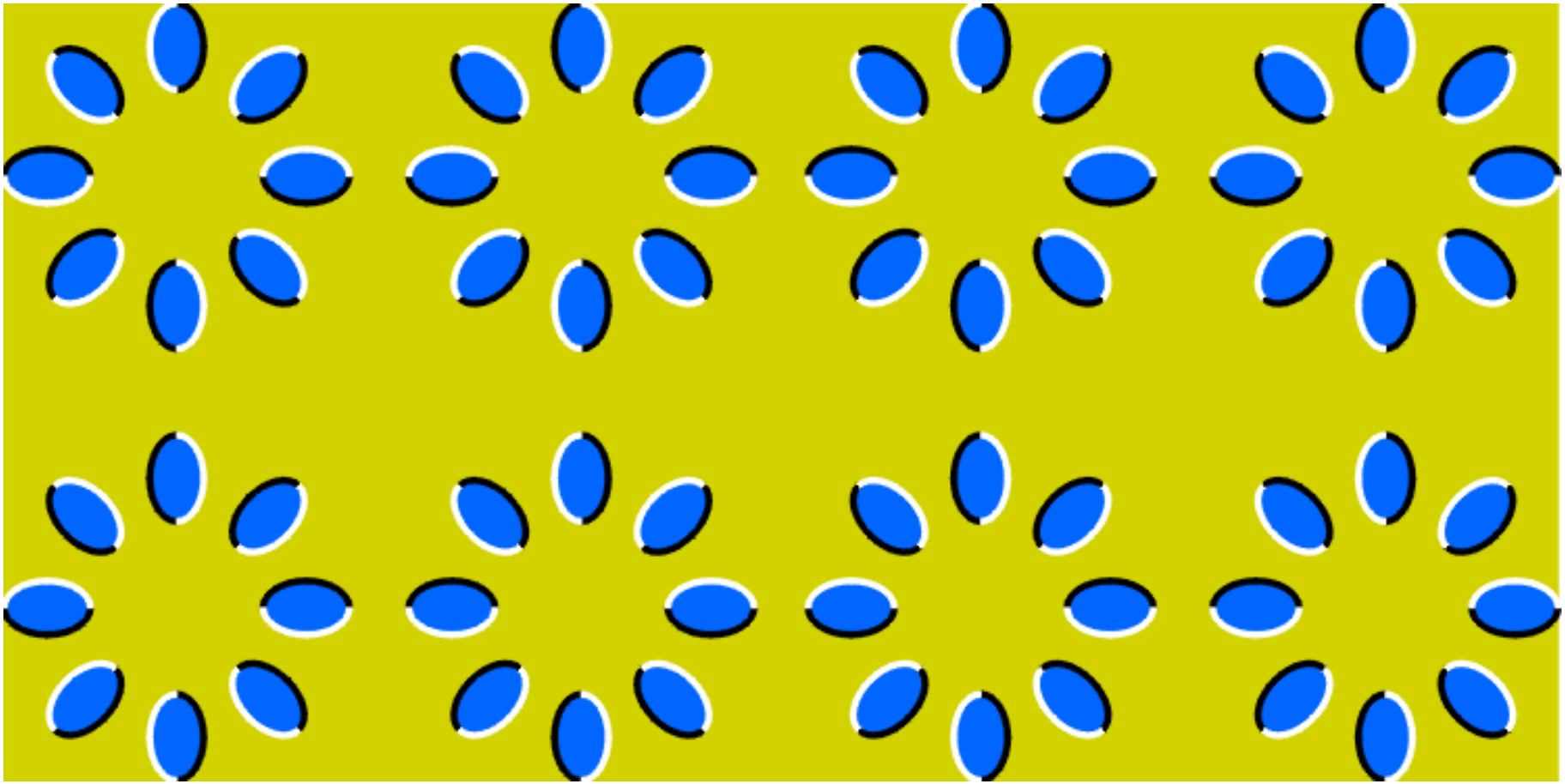
# Optical Illusions



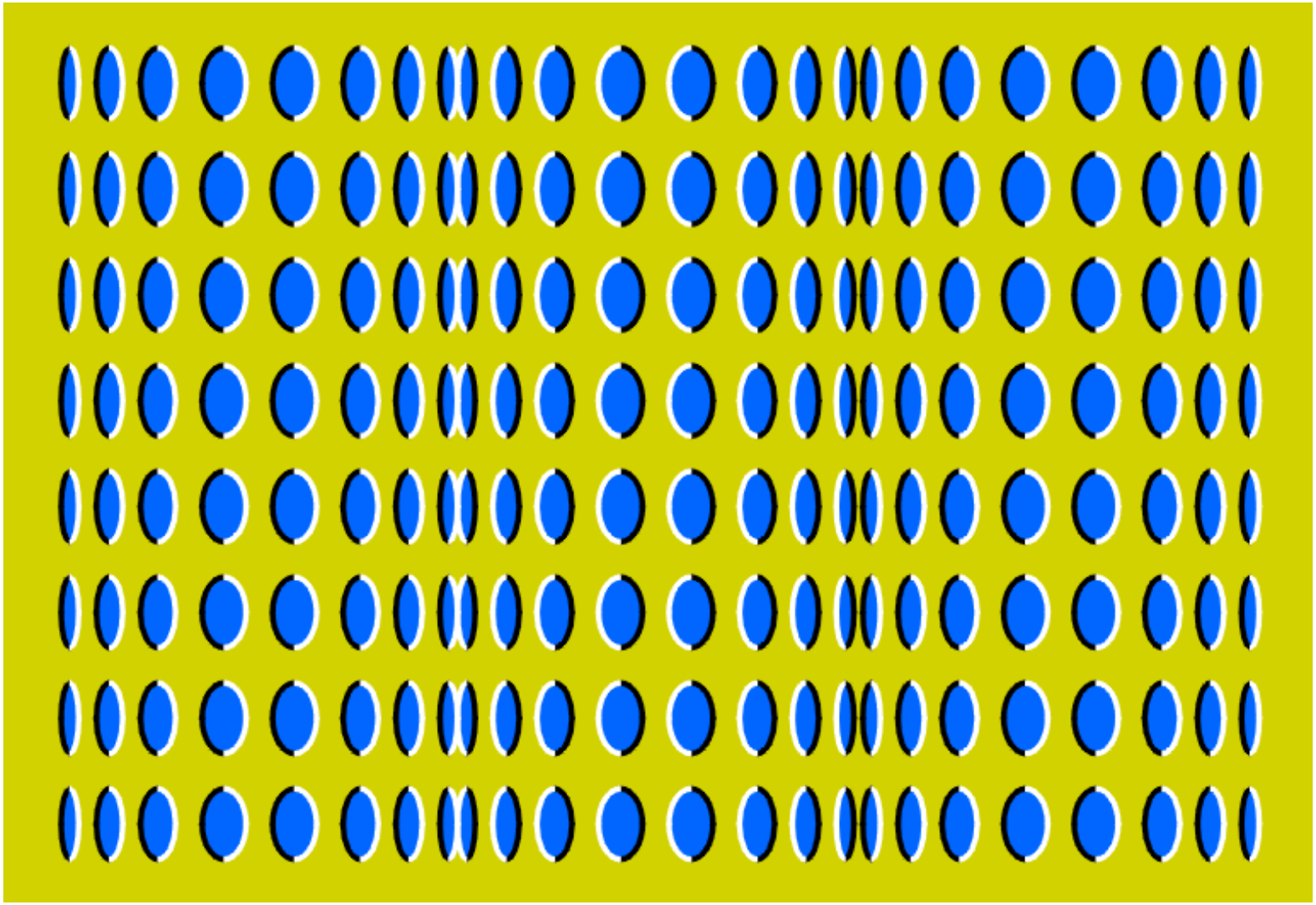
the Ponzo illusion

the Muller Lyer illusion

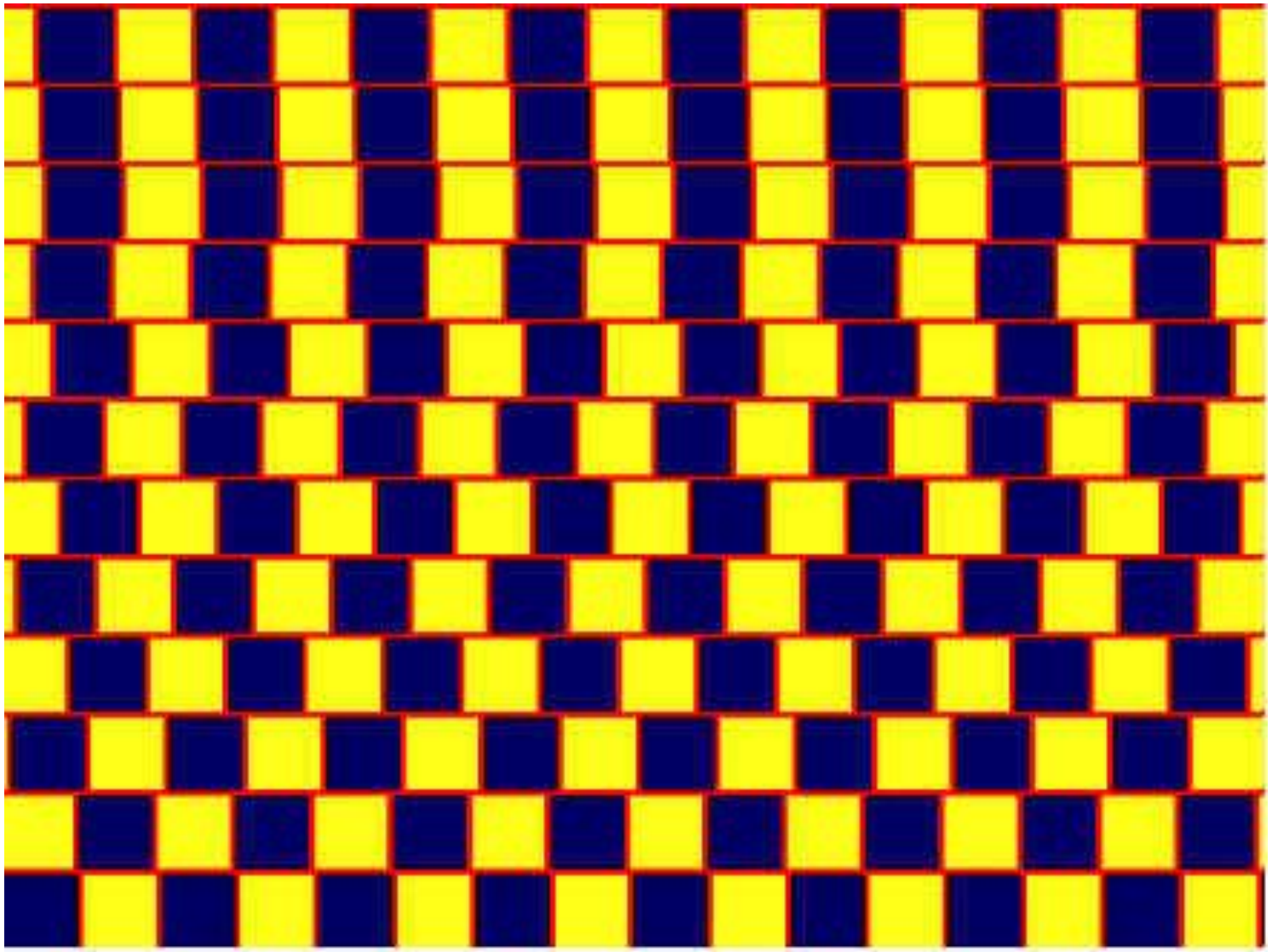
# Optical Illusions



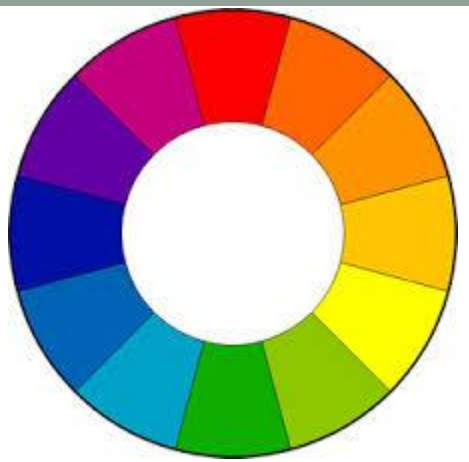
# Optical Illusions



# Optical Illusions



# Colors



- Major impact in UI design
- Beyond pure aesthetics, color has associated meanings  (Cultural differences) and elicits emotional responses.
- To prevent confusion in meaning, color must be used consistently
- An UI must be designed without colors in the beginning
- Magic number: 5±2 colors in an interface
- For different concepts – use different colors

# Accessibility

The primary colors as seen with normal color vision.

The primary colors as seen with Protanopia (1% of male population).

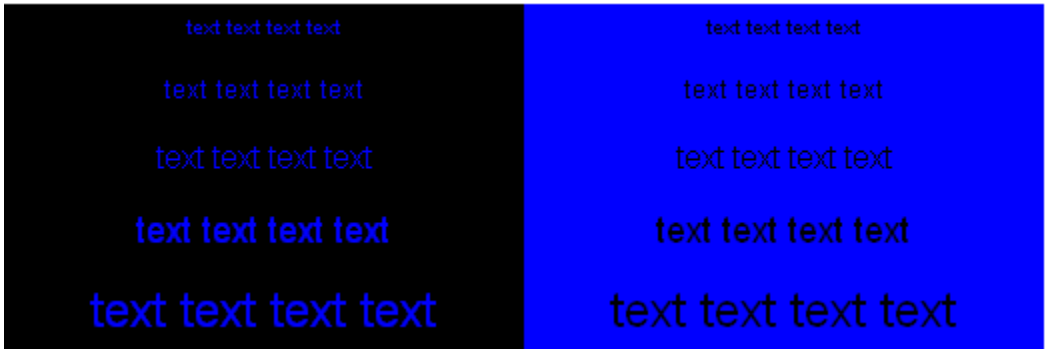
The primary colors as seen with Deuteranopia (6% of male population).

The primary colors as seen with Tritanopia (1% of male population).

# “Designing with blue”

- There are special usability issues to be considered in using blue and yellow in graphics.
- Legibility, temporal response, spatial localization and perception of geometrical shapes are all somewhat compromised in patterns in which the only differences are in the short-wave-sensitive (SWS, "blue") photoreceptors.
- In graphics terms this mostly applies to color pairs that differ only in the blue primary.
- recommendation: “Pure blue should not be used for fine detail or background “

# Legibility

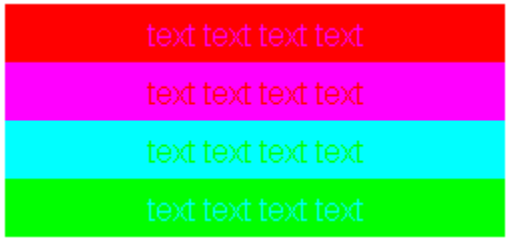



- Difficult to read in any font size
- Text differ from their backgrounds only in the blue primary:









# Solutions

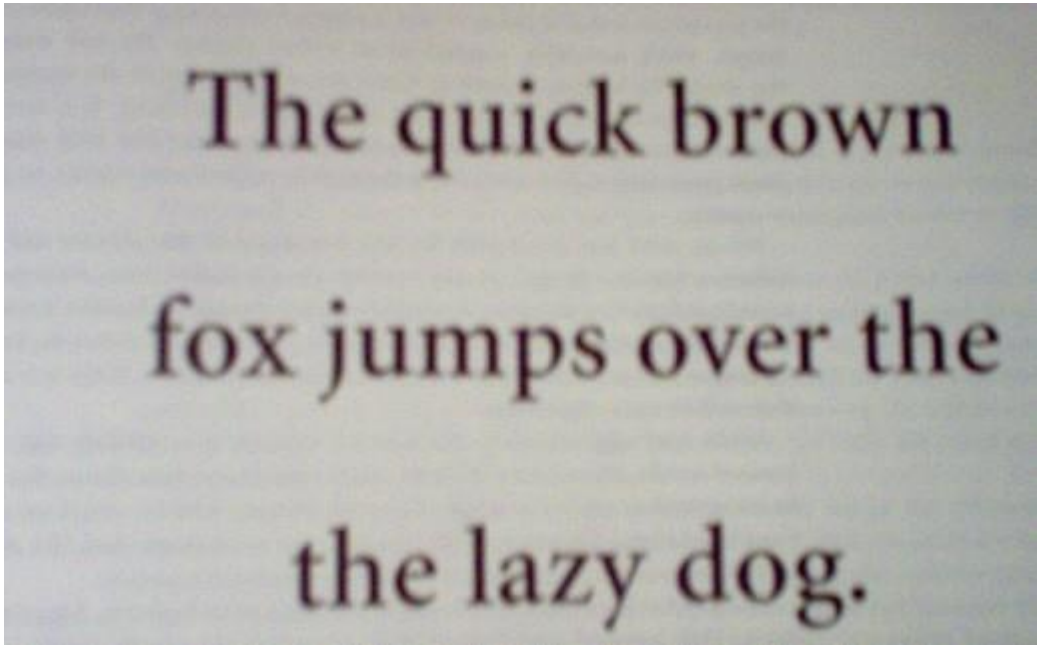


**Blue can be used in most contexts if care is taken to achieve adequate luminance contrast.**

# Reading

- Several stages:
  - visual pattern perceived
  - decoded using internal representation of language
  - interpreted using knowledge of syntax, semantics, pragmatics
- Reading involves saccades and fixations
- Perception occurs during fixations
- Word shape is important to recognition
- Negative contrast improves reading from computer screen

# Reading



# Can you read this?

- I cnduo't bvleiee taht I culod aulaclty uesdtannrd waht I was rdnaieg. Unisg the icndeblire pweor of the hmuan mnid, aocdcrnig to rseecrah at Cmabrigde Uinervtisy, it dseno't mttaer in waht oderr the lterets in a wrod are, the olny irpoamtnt tihng is taht the frsit and lsat ltteer be in the rhgit pclae. The rset can be a taotl mses and you can sitll raed it whoutit a pboerlm. Tihs is bucseae the huamn mnid deos not raed ervey ltteer by istlef, but the wrod as a wlohe. Aaznmig, huh?

# Correct paragraph

- I couldn't believe that I could actually understand what I was reading. Using the incredible power of the human brain, according to research at Cambridge University, it doesn't matter in what order the letters in a word are, the only important thing is that the first and last letter be in the right place. The rest can be a total, mess and you can read it without a problem. This is because the human mind does not read every letter by itself, but the word as a whole. Amazing, huh?

# Hearing


- Provides information about environment:
  distances, directions, objects etc.

- Physical apparatus:
  - outer ear – protects inner and amplifies sound
  - middle ear – transmits sound waves as vibrations to inner ear
  - inner ear – chemical transmitters are released and cause impulses in auditory nerve
- Sound
  - pitch – sound frequency
  - loudness – amplitude
  - timbre – type or quality

# Hearing

- Humans can hear frequencies from 20Hz to 15kHz
  - less accurate distinguishing high frequencies than low.

- Auditory system filters sounds
  - can attend to sounds over background noise.
  - for example, the **cocktail party** phenomenon - when one may immediately detect words of importance originating from unattended stimuli, for instance hearing one's name in another conversation

# Touch

- Provides important feedback about environment.
- May be key sense for someone who is visually impaire
- Stimulus received via receptors in the skin:
  - thermoreceptors – heat and cold
  - nociceptors – pain
  - mechanoreceptors – pressure
    (some instant, some continuous)
- Some areas more sensitive than others e.g. fingers.
- Kinesthesis - awareness of body position
  - affects comfort and performance.

# Movement

- Time taken to respond to stimulus:
  reaction time + movement time
- Movement time dependent on age, fitness etc.

- Reaction time - dependent on stimulus type:
  - visual ~ 200ms
  - auditory ~ 150 ms
  - pain ~ 700ms

- Increasing reaction time decreases accuracy in the unskilled operator but not in the skilled operator.

# Movement

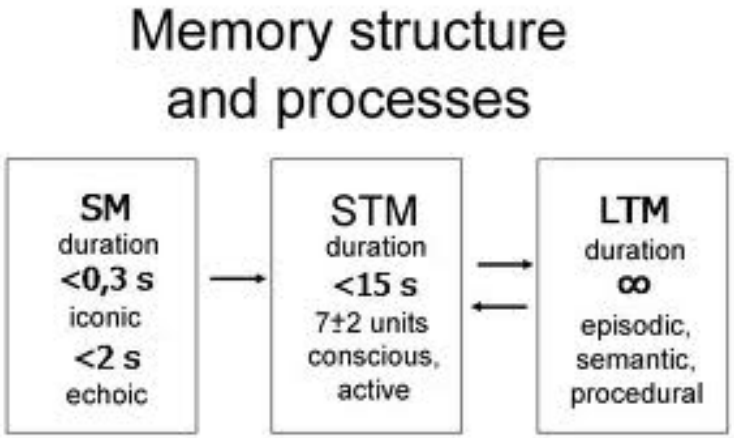
- Fitts' Law describes **the time taken to hit a screen target**:

$$M_t = a + b \log_2(D/S + 1)$$

where: a and b are empirically determined constants
$M_t$ is movement time
D is Distance
S is Size of target

⇒ targets as large as possible
distances as small as possible

# Memory




There are three types of memory function:

Sensory memories

Attention

Short-term memory or working memory

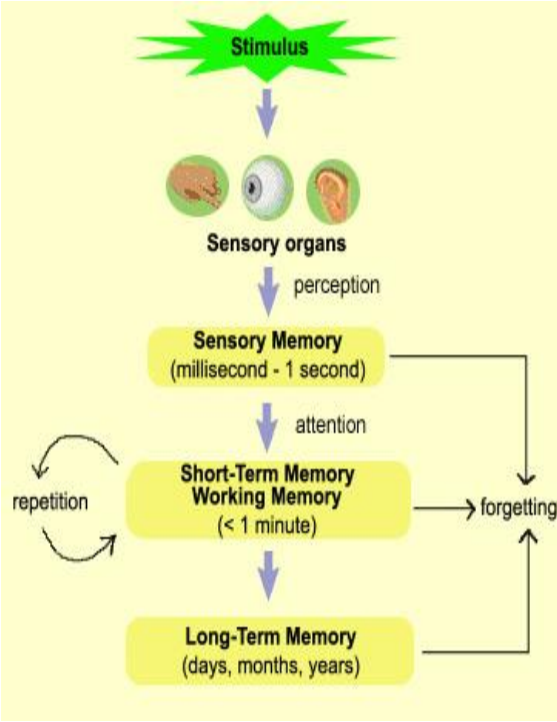
Rehearsal

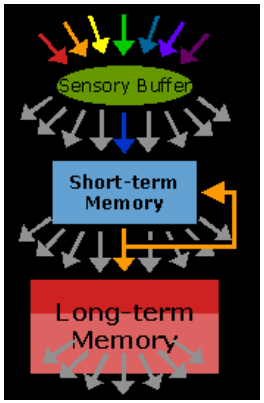
Long-term memory

Selection of stimuli governed by level of arousal.

# Sensory memory

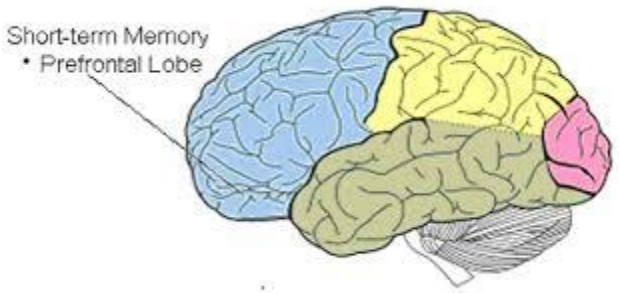
- Buffers for stimuli received through senses
  - iconic memory: visual stimuli
  - echoic memory: aural stimuli
  - haptic memory: tactile stimuli
- Examples
  - “sparkler” trail
  - stereo sound
- Continuously overwritten

# Short-term memory (STM)

- Scratch-pad for temporary recall
  - rapid access ~ 70ms
  - rapid decay ~ 200ms
  - limited capacity - 7± 2 chunks



# STM

Try to memorize as much as possible from the following sequence

265397620853

Try to memorize as much as possible from the following sequence

0040 732 215 754

# Examples

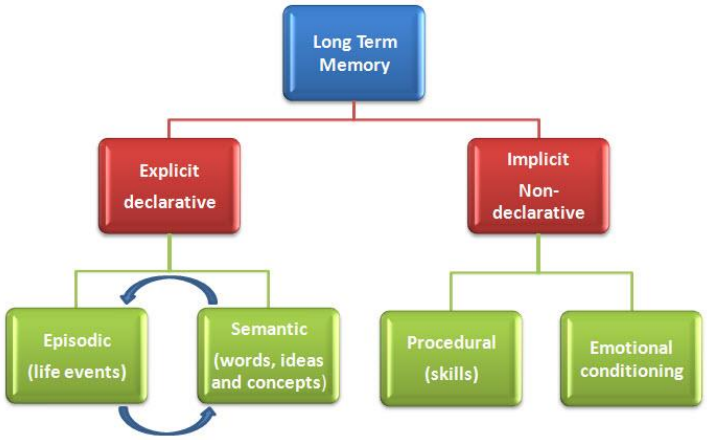
212348278493202

0121 414 2626

HEC ATR ANU PTH ETR EET

# Long-term memory (LTM)

- Repository for all our knowledge
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge or unlimited capacity




- Two types
  - episodic – serial memory of events collection of past personal experiences that occurred at a particular time and place
  - semantic – structured memory of facts, concepts, skills - refers to general world knowledge that we have accumulated throughout our lives

semantic LTM derived from episodic LTM

# Long-term memory

- Semantic memory structure
  - provides access to information
  - represents relationships between bits of information
  - supports inference
- Model: semantic network
  - inheritance – child nodes inherit properties of parent nodes
  - relationships between bits of information explicit
  - supports inference through inheritance

# LTM - Forgetting

decay

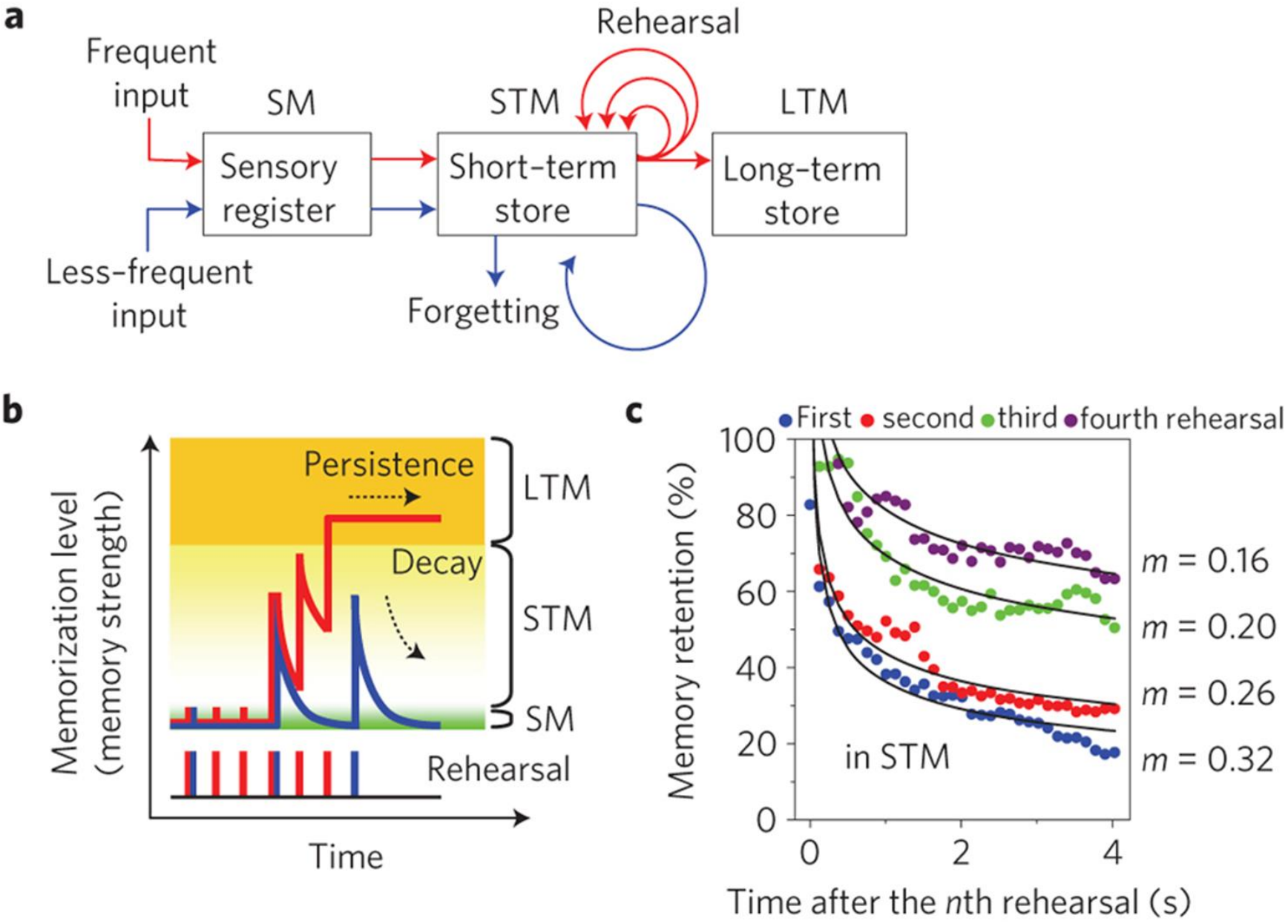
- information is lost gradually but very slowly

interference

- new information replaces old: retroactive interference
- old may interfere with new: proactive inhibition

so may not forget at all memory is selective …

… affected by emotion – can subconsciously `choose' to forget


a
Frequent input
Less-frequent input
SM
Sensory register
STM
Short-term store
Rehearsal
LTM
Long-term store
Forgetting
b
Memorization level (memory strength)
Persistence
Decay
LTM
STM
SM
Rehearsal
Time
c
First second third fourth rehearsal
Memory retention (%)
100
80
60
40
20
0
in STM
m = 0.16
m = 0.20
m = 0.26
m = 0.32
0
2
4
Time after the nth rehearsal (s)

# LTM - retrieval

recall

- information reproduced from memory can be assisted by cues, e.g. categories, imagery

recognition

- information gives knowledge that it has been seen before
- less complex than recall - information is cue

# THINKING

Reasoning

deduction, induction, abduction

Problem solving

# Deductive Reasoning

- Deduction:
  - derive logically necessary conclusion from given premises.

    e.g. If it is Friday then she will go to work
    It is Friday
    Therefore she will go to work.

- Logical conclusion not necessarily true:

    e.g. If it is raining then the ground is dry
    It is raining
    Therefore the ground is dry

# Deduction

- When truth and logical validity clash …

  e.g. Some people are babies

  Some babies cry

  Inference - Some people cry

  Correct?

- People bring world knowledge to bear

# Inductive Reasoning

- Induction:
  - generalize from cases seen to cases unseen

    e.g. all elephants we have seen have trunks
    therefore all elephants have trunks.

- Unreliable:
  - can only prove false not true

  … but useful!

- Humans not good at using negative evidence

  e.g. Wason's cards.

# Wason's cards


If a card has a vowel on one side it has an even number on the other

Which of these cards are worth turning over if you want to know whether the statement below is **false**?

# Wason’s cards

- The only way to falsify an "if X, then Y" statement ("if vowel, then even number") is by finding an instance of "X and not Y" ("vowel and odd number").

- K and 4 are irrelevant, because these cards cannot combine a vowel and odd number.

# Wason's Cards


- 128 university students tested
- "E and 4" was the most common response (given by 59 people), and "E" was the next most common (given by 42).
- students chose the cards capable of confirming the statement rather than disconfirming it.
- The tendency to seek out confirming evidence is known as a "confirmation bias."

# Abductive reasoning

- reasoning from event to cause

  e.g. Sam drives fast when drunk.

  If I see Sam driving fast, assume drunk.

- Unreliable:
  - can lead to false explanations

# Reasoning

Deductive, Inductive, and Abductive Syllogisms

| Deductive | Inductive | Abductive |
|---|---|---|
| All men are mortal; | Socrates is a man; | All men are mortal; |
| Socrates is a man; | Socrates is mortal; | Socrates is mortal; |
| ∴ Socrates is mortal. | ∴ All men are mortal. | ∴ Socrates is a man. |

Adapted from: Hui, J., Cashman, T. and T. Deacon. 2008. Salzano's Method: Double Description: What is It? How Does It Work? What Do We Learn? in J. Hoffmeyer (ed.) A Legacy for Living Systems: Gregory Bateson As Precursor to Biosemiotics.

# Problem solving

- Process of finding solution to unfamiliar task using knowledge.
- Several theories
- Gestalt
  - Gestalt psychologists find it is important to think of problems as a whole problem solving both productive and reproductive
  - **Productive** thinking is solving a problem with insight.
  - This is a quick insightful unplanned response to situations and environmental interaction.
  - **Reproductive** thinking is solving a problem with previous experiences and what is already known.

# Problem solving

Problem space theory

- problem space comprises problem states
- problem solving involves generating states using legal operators
- heuristics may be employed to select operators
  e.g. means-ends analysis
- operates within human information processing system
  e.g. STM limits etc.
- largely applied to problem solving in well-defined areas
  e.g. puzzles rather than knowledge intensive areas

# Problem solving

- Analogy
  - analogical mapping:
    - novel problems in new domain?
    - use knowledge of similar problem from similar domain
  - analogical mapping difficult if domains are semantically different

- Skill acquisition
  - skilled activity characterized by chunking
    - lot of information is chunked to optimize STM
  - conceptual rather than superficial grouping of problems
  - information is structured more effectively

# Errors and mental models

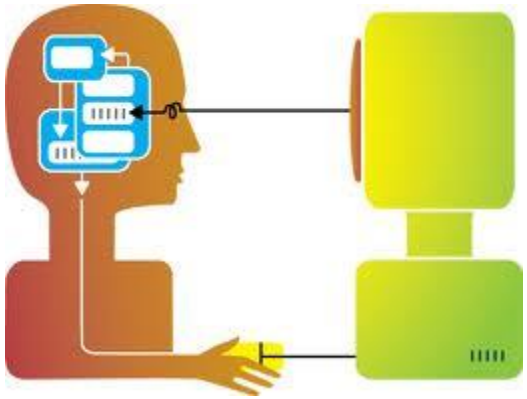
Types of error

- slips
  - right intention, but failed to do it right
  - causes: poor physical skill, inattention etc.
  - change to aspect of skilled behaviour can cause slip
- mistakes
  - wrong intention
  - cause: incorrect understanding

humans create mental models to explain behaviour.
if wrong (different from actual system) errors can occur

# Mental models

- *"The image of the world around us, which we carry in our head, is just a model. Nobody in his head imagines all the world, government or country. He has only selected concepts, and relationships between them, and uses those to represent the real system.“ (*Jay Wright Forrester – MIT professor*)*



# Everyday Life and Mental Models

(a) You arrive home on a cold winter's night to a cold house. How do you get the house to warm up as quickly as possible? Set the thermostat to be at its highest or to the desired temperature?

(b) You arrive home starving hungry. You look in the fridge and find all that is left is an uncooked pizza. You have an electric oven. Do you warm it up to 200 degrees first and then put it in (as specified by the instructions) or turn the oven up higher to try to warm it up quicker?

# Exercise: ATMs

- How an ATM works
  - How much money are you allowed to take out?
  - What denominations?
  - If you went to another machine and tried the same what would happen?
  - What information is on the strip on your card? How is this used?
  - What happens if you enter the wrong number?
  - Why are there pauses between the steps of a transaction? What happens if you try to type during them?
  - Why does the card stay inside the machine?
  - Do you count the money? Why?

# How did you fare?

- Your mental model
  - How accurate?
  - How similar?
  - How superficial?

- Payne (1991) did a similar study and found that people frequently resort to analogies to explain how things work

# Computers…

- Same is often true for understanding how interactive devices and computers work:
  - Poor, often incomplete, easily confusable, based on inappropriate analogies and superstition (Norman, 1983)
  - e.g. frozen cursor/screen - most people will bash all manner of keys

# External cognition

- Concerned with explaining how we interact with external representations (e.g. maps, notes, diagrams)
- What are the cognitive benefits and what processes involved
- How they extend our cognition
- What computer-based representations can we develop to help even more?

# External cognition

- It is recommended to design user flows that relieve users of **memory load** through **external cognition**

- **External cognition** is the information processing that goes on between the internal cognition of the human mind and the perception and manipulation of its external representations

- Calendars, spreadsheets and calculators, as well as checklists and annotations are just several of the widely used tools and products that exhibit the benefits of utilizing external cognition.

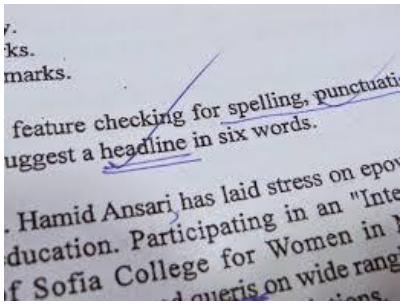
# Externalizing to reduce memory load

- Diaries, reminders, calendars, notes, shopping lists, to-do lists - written to remind us of what to do
- Post-its, piles, marked emails - where placed indicates priority of what to do
- External representations:
  - Remind us that **we need to do** something (e.g. to buy something for mother's day)
  - Remind us of **what to do** (e.g. buy a card)
  - Remind us **when to do something** (e.g. send a card by a certain date)

# Computational offloading

- When a tool is used in conjunction with an external representation to carry out a computation (e.g. pen and paper)
- Try doing the two sums below (a) in your head, (b) on a piece of paper and c) with a calculator.
  - 234 x 456 =??
  - CCXXXIV x CCCCXXXXXVI = ???
- Which is easiest and why? Both are identical sums

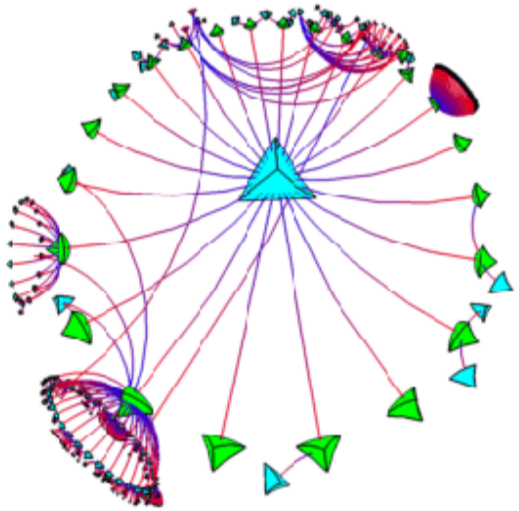
# Annotation and cognitive tracing




- Annotation involves modifying existing representations through making marks
  - e.g. crossing off, ticking, underlining
  - allowing users to make annotations has the added benefit of permitting large amounts of information to be synthesized into small, personalized notes
- Cognitive tracing involves externally manipulating items into different orders or structures
  - e.g. playing scrabble, playing cards

# Design implication

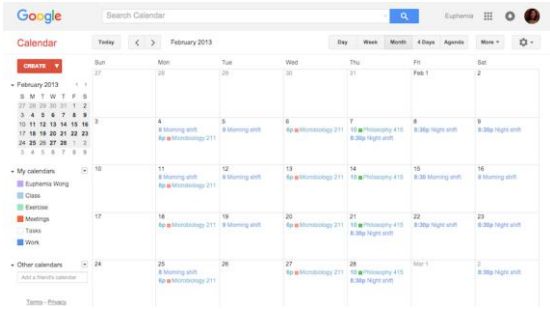
- Provide external representations at the interface that reduce memory load and facilitate computational offloading

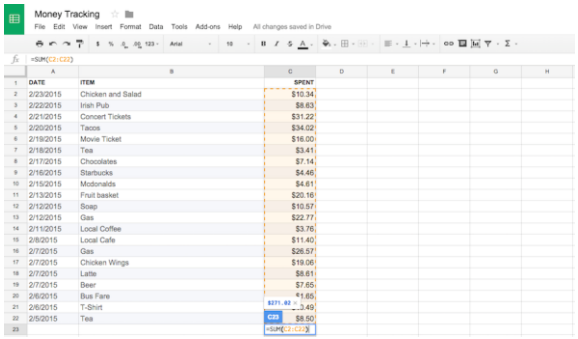


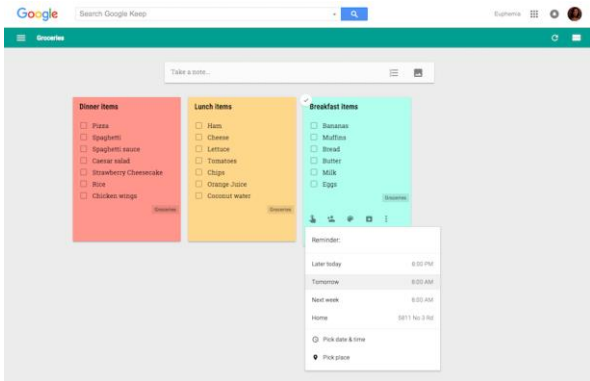
e.g. Information visualizations have been designed to allow people to make sense and rapid decisions about masses of data

# Examples

- **Externalizing to Reduce Memory Load**
  - **Google Calendar**
- **Computational Offloading**
  - Google Sheets
- **Annotations and Cognitive Tracing**
  - Google Keep



# Mental models & system design

- Notion of mental models has been used as a basis for conceptual models
- Assumption is that if you can understand how people develop mental models then can help them develop more appropriate mental models of system functionality
- Design principle: try to make systems transparent so people can understand them better and know what to do

# The design principle of transparency

- useful feedback
- easy to understand
- intuitive to use
- clear & easy to follow instructions
- appropriate online help
- context sensitive guidance of how to proceed when stuck

# Emotions

- Various theories of how emotion works
  - James-Lange: emotion is our interpretation of a physiological response to a stimuli
  - Cannon: emotion is a psychological response to a stimuli
  - Schacter-Singer: emotion is the result of our evaluation of our physiological responses, in the light of the whole situation we are in
- Emotion clearly involves both cognitive and physical responses to stimuli

# Emotions

- The biological response to physical stimuli is called *affect*

- Affect influences how we respond to situations
  - positive → creative problem solving
  - negative → narrow thinking

"Negative affect can make it harder to do even easy tasks; positive affect can make it easier to do difficult tasks"

(Donald Norman)

# Emotion

- Implications for interface design
  - stress will increase the difficulty of problem solving
  - relaxed users will be more forgiving of shortcomings in design
  - aesthetically pleasing and rewarding interfaces will increase positive affect (Attractive things work better?)

# Psychology and the Design of Interactive System

- Some direct applications
  - e.g. blue acuity is poor
    $\Rightarrow$ blue should not be used for important detail

- However, correct application generally requires understanding of context in psychology, and an understanding of particular experimental conditions

- A lot of knowledge has been distilled in
  - guidelines
  - cognitive models
  - experimental and analytic evaluation techniques

# THE COMPUTER

HCI Basics

# The Computer

a computer system is made up of various elements

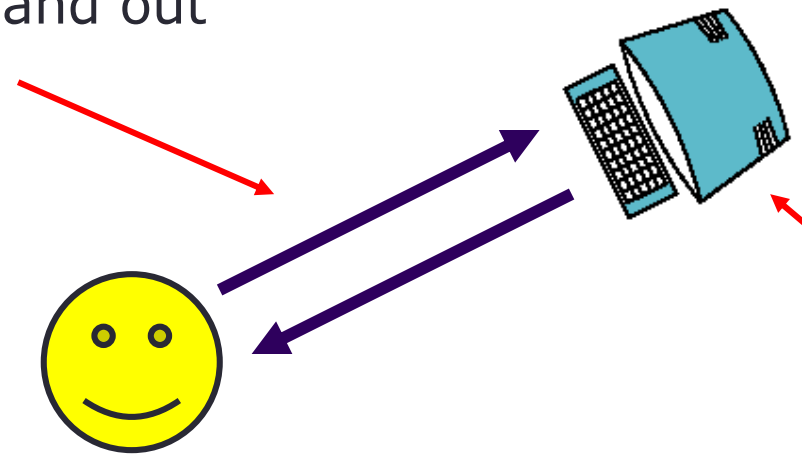
each of these elements affects the interaction

- input devices – text entry and pointing
- output devices – screen (small&large), digital paper
- virtual reality – special interaction and display devices
- physical interaction – e.g. sound, haptic, bio-sensing
- paper – as output (print) and input (scan)
- memory – RAM & permanent media, capacity & access
- processing – speed of processing, networks

# Interacting with computers

to understand human–*computer* interaction
… need to understand computers!

what goes in and out
devices, paper,
sensors, etc.



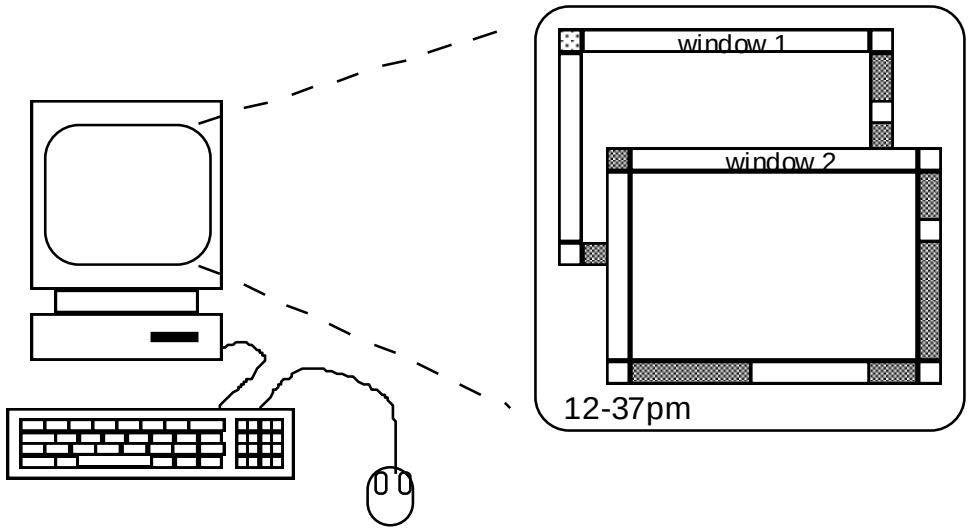
what can it do?
memory, processing,
networks

# A ‘typical’ computer system

?

- screen, or monitor, on which there are windows
- keyboard
- mouse/trackpad

- variations
  - desktop
  - laptop
  - PDA




the devices dictate the styles of interaction that the system supports

If we use different devices, then the interface will support a different style of interaction

# How many …

- computers in your house?
  - hands up, …
    … none, 1, 2 , 3, more!!
- computers in your pockets?

are you thinking …
… PC, laptop, PDA ??

# How many computers …

in your house?

- PC
- TV, VCR, DVD, HiFi, cable/satellite TV
- microwave, cooker, washing machine
- central heating
- security system

can you think of more?

in your pockets?

- PDA
- phone, camera
- smart card, card with magnetic strip?
- electronic car key
- USB memory

try your pockets and bags

# Interactivity?

Long ago in a galaxy far away … *batch* processing

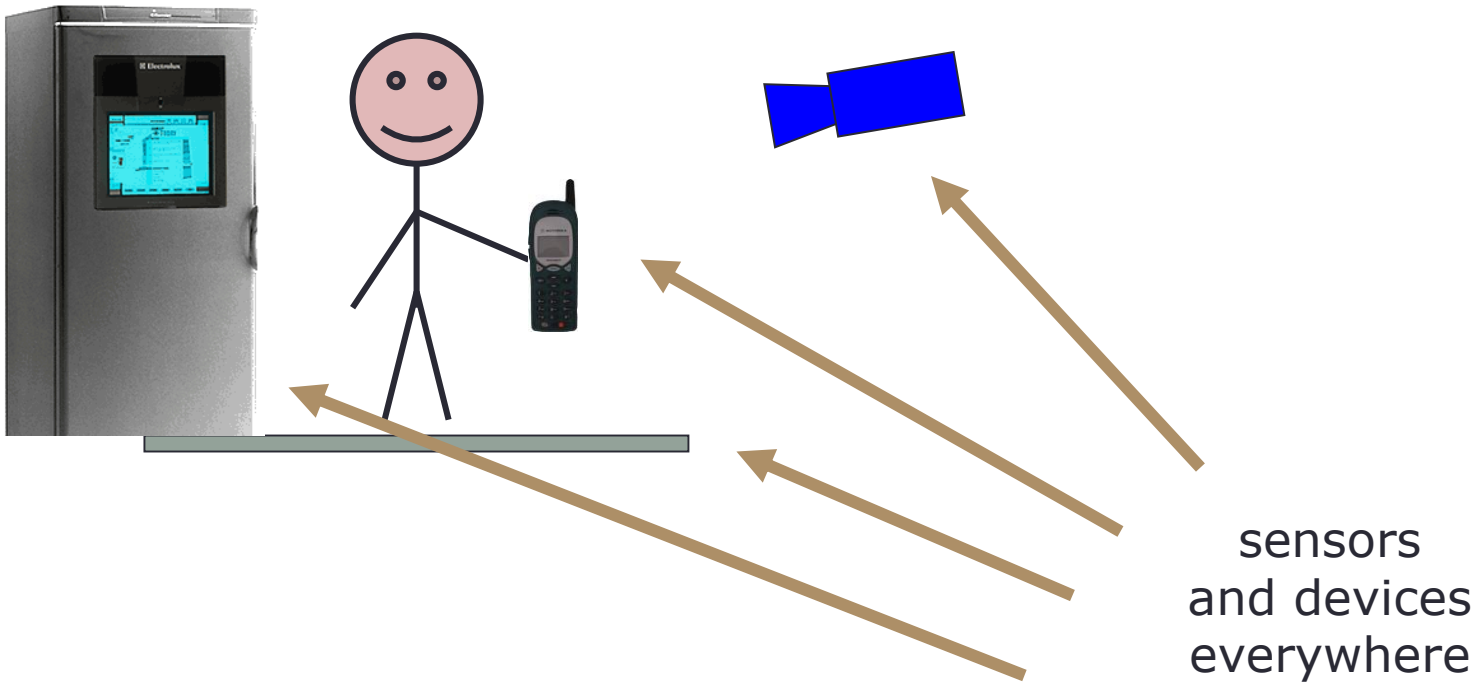
- punched card stacks or large data files prepared
- long wait ….
- line printer output

  … and if it is not right …

Now most computing is interactive

- rapid feedback
- the user in control (most of the time)
- **doing rather than thinking …**

# Richer interaction



# TEXT ENTRY DEVICES

keyboards (QWERTY et al.)

chord keyboards, phone pads

handwriting, speech

# Keyboards

- Most common text input device
- Allows rapid entry of text by experienced users
- Keypress closes connection, causing a character code to be sent
- Usually connected by cable, but can be wireless

# layout – QWERTY

- Standardised layout

  but …
  - non-alphanumeric keys are placed differently
  - accented symbols needed for different scripts
  - minor differences between UK and USA keyboards

- QWERTY arrangement not optimal for typing

  – layout to prevent typewriters jamming!

- Alternative designs allow faster typing but large social base of QWERTY typists produces reluctance to change.

# Alternative keyboard layouts

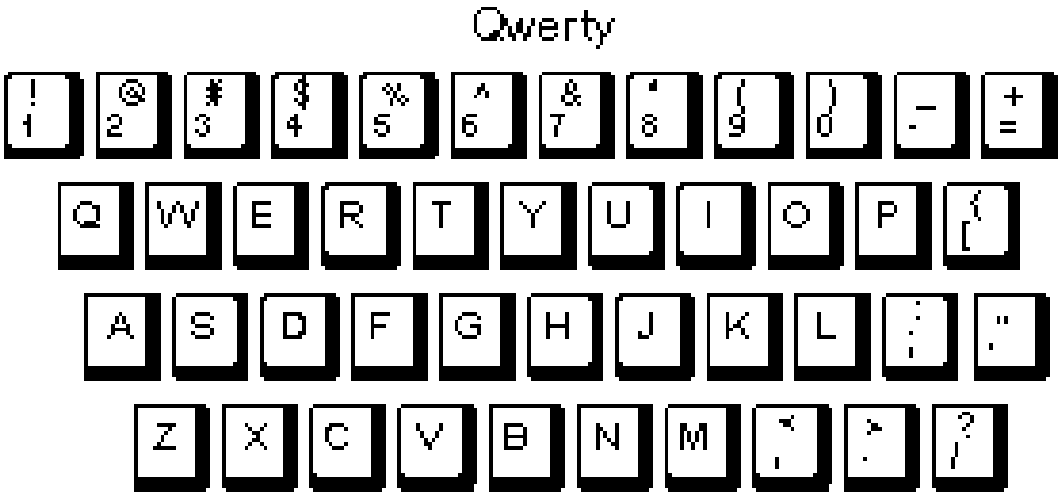
## Alphabetic

- keys arranged in alphabetic order
- not faster for trained typists
- not faster for beginners either!

## Dvorak

- common letters under dominant fingers
- biased towards right hand
- common combinations of letters alternate between hands
- 10-15% improvement in speed and reduction in fatigue
- But - large social base of QWERTY typists produce market pressures not to change

# QWERTY vs Dvorak



# Special keyboards

- designs to reduce fatigue for RSI
- for one handed use

    e.g. the Maltron left-handed keyboard

# Chord keyboards

only a few keys - four or 5

letters typed as combination of keypresses

compact size

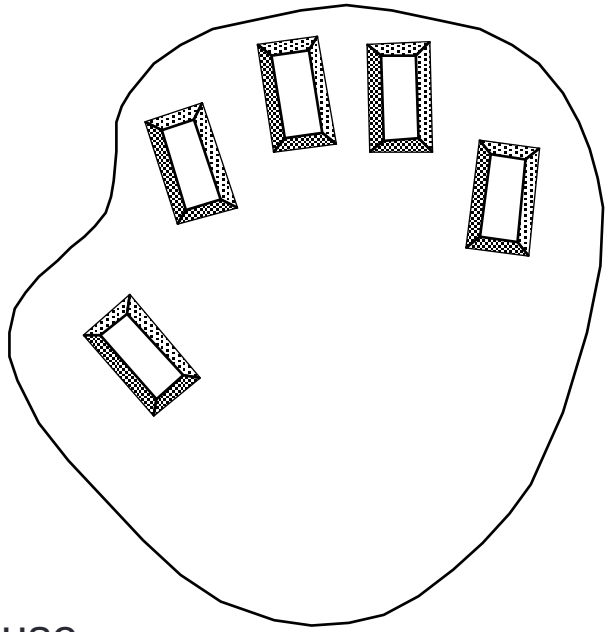
– ideal for portable applications

short learning time

– keypresses reflect letter shape

fast

– once you have trained



BUT - social resistance, plus fatigue after extended use

NEW – niche market for some wearables

# Phone pad and T9 entry

- use numeric keys with multiple presses

  2 – a b c  6 - m n o
  3 - d e f  7 - p q r s
  4 - g h i  8 - t u v
  5 - j k l  9 - w x y z

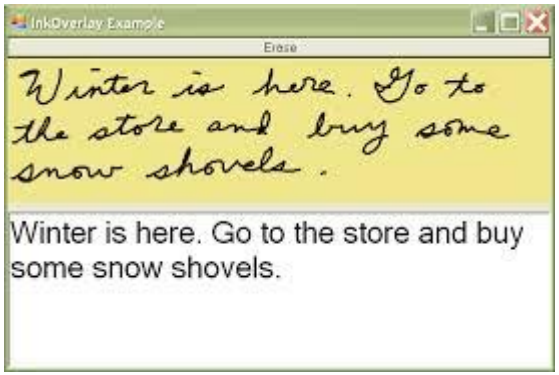
  hello = 4433555[pause]555666

  surprisingly fast!

- T9 predictive entry
  - type as if single key for each letter
  - use dictionary to ‘guess’ the right word
  - hello = 43556 …
  - but 26 -> menu ‘am’ or ‘an’

# Handwriting recognition

- Text can be input into the computer, using a pen and a digesting tablet
  - natural interaction
- Technical problems:
  - capturing all useful information - stroke path, pressure, etc. in a natural manner
  - segmenting joined up writing into individual letters
  - interpreting individual letters
  - coping with different styles of handwriting
- Used in PDAs, and tablet computers …
  … leave the keyboard on the desk!



# Speech recognition

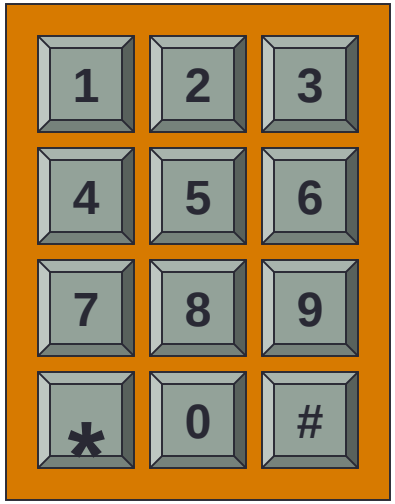
- Improving rapidly
- Most successful when:
  - single user – initial training and learns peculiarities
  - limited vocabulary systems
- Problems with
  - external noise interfering
  - imprecision of pronunciation
  - large vocabularies
  - different speakers

# Numeric keypads

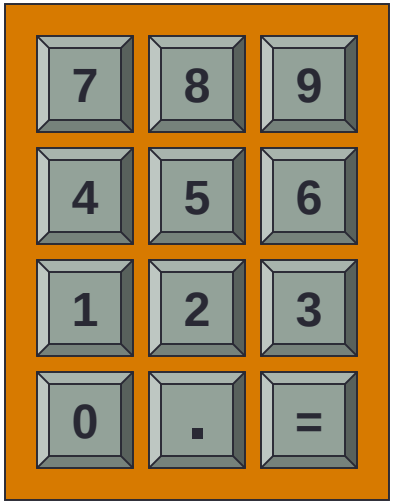
- for entering numbers quickly:
  - calculator, PC keyboard
- for telephones

not the same!!

ATM like phone




telephone




calculator

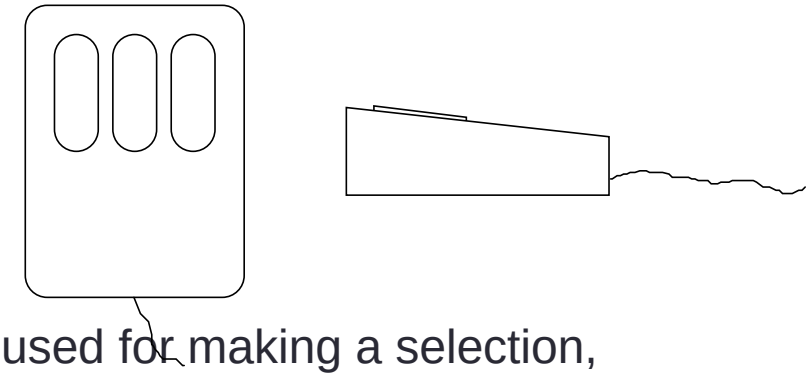
# POSITIONING, POINTING AND DRAWING

mouse, touchpad
trackballs, joysticks etc.
touch screens, tablets
eyegaze, cursors

# The Mouse

- Handheld pointing device
  - very common
  - easy to use

- Two characteristics
  - planar movement
  - buttons

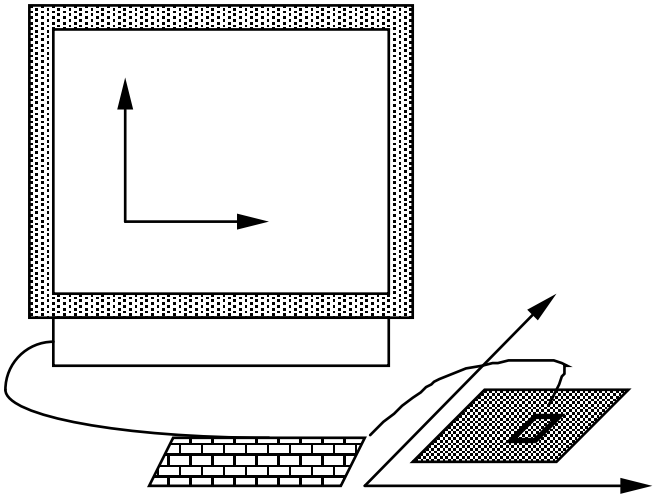


(usually from 1 to 3 buttons on top, used for making a selection, indicating an option, or to initiate drawing etc.)

# The mouse

Mouse located on desktop

- requires physical space
- no arm fatigue



Relative movement only is detectable.

Movement of mouse moves screen cursor

Screen cursor oriented in (x, y) plane,
mouse movement in (x, z) plane …

… an *indirect* manipulation device.

- device itself doesn't obscure screen, is accurate and fast.
- hand-eye coordination problems for novice users

# How does it work?

Two methods for detecting motion

- Mechanical
  - Ball on underside of mouse turns as mouse is moved
  - Rotates orthogonal potentiometers
  - Can be used on almost any flat surface
- Optical
  - light emitting diode on underside of mouse
  - may use special grid-like pad or just on desk
  - less susceptible to dust and dirt
  - detects fluctuating alterations in reflected light intensity to calculate relative motion in (x, z) plane

# Even by foot …

- some experiments with the *footmouse*
  - controlling mouse movement with feet …
  - not very common :-)

- but foot controls are common elsewhere:
  - car pedals
  - sewing machine speed control
  - organ and piano pedals

# Touchpad

- small touch sensitive tablets
- ‘stroke’ to move mouse pointer
- used mainly in laptop computers

- good ‘acceleration’ settings important
  - fast stroke
    - lots of pixels per inch moved
    - initial movement to the target
  - slow stroke
    - less pixels per inch
    - for accurate positioning

# Trackball and thumbwheels

## Trackball

- ball is rotated inside static housing
  - like an upsdie down mouse!
- relative motion moves cursor
- indirect device, fairly accurate
- separate buttons for picking
- very fast for gaming
- used in some portable and notebook computers.

## Thumbwheels …

- for accurate CAD – two dials for X-Y cursor position
- for fast scrolling – single dial on mouse

# Joystick and keyboard nipple

## Joystick

- indirect
  pressure of stick = velocity of movement
- buttons for selection
  on top or on front like a trigger
- often used for computer games
  aircraft controls and 3D navigation

## Keyboard nipple

- for laptop computers
- miniature joystick in the middle of the keyboard

# Touch-sensitive screen

- Detect the presence of finger or stylus on the screen.
  - works by interrupting matrix of light beams,  capacitance changes or ultrasonic reflections
  - *direct* pointing device
- Advantages:
  - fast, and requires no specialised pointer
  - good for menu selection
  - suitable for use in hostile environment: clean and safe from damage.
- Disadvantages:
  - finger can mark screen
  - imprecise (finger is a fairly blunt instrument!)
    - difficult to select small regions or perform accurate drawing
  - lifting arm can be tiring

# Stylus and light pen

Stylus

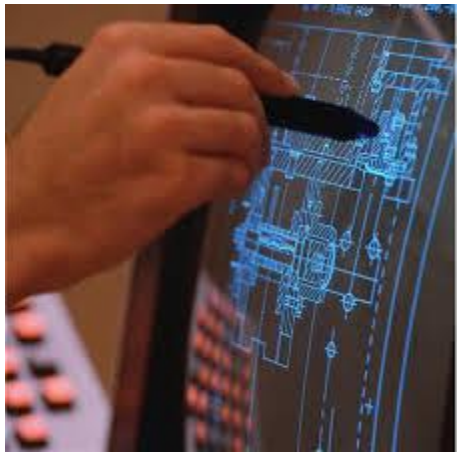
- small pen-like pointer to draw directly on screen
- may use touch sensitive surface or magnetic detectio
- used in PDA, tablets PCs and drawing tables

Light Pen

- now rarely used
- uses light from screen to detect location

BOTH …

- very direct and obvious to use
- but can obscure screen



# Digitizing tablet

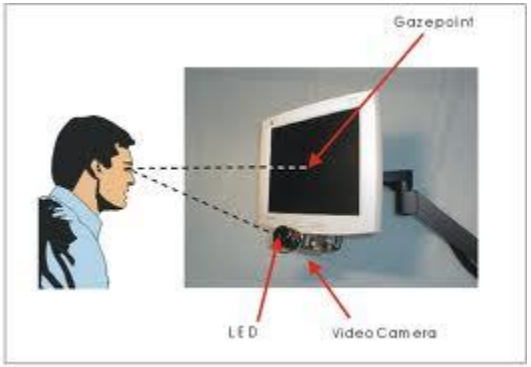
- Mouse like-device with cross hairs

- used on special surface
  - rather like stylus

- very accurate
  - used for digitizing maps

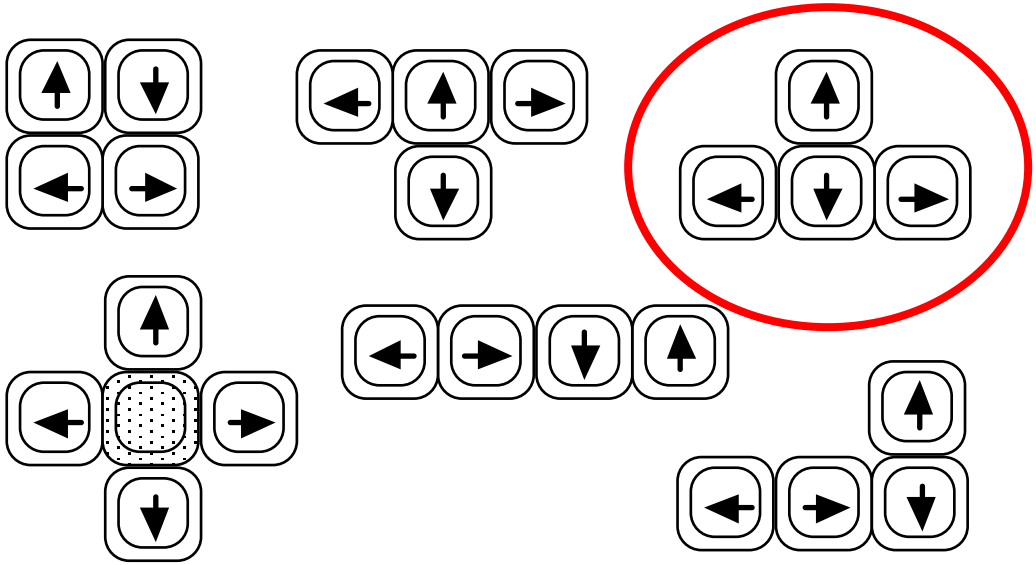
# Eyegaze

- control interface by eye gaze direction
  - e.g. look at a menu item to select it
- uses laser beam reflected off retina
  - … a very low power laser!
- mainly used for evaluation
- potential for hands-free control
- high accuracy requires headset
- cheaper and lower accuracy devices available
  sit under the screen like a small webcam



# Cursor keys

- Four keys (up, down, left, right) on keyboard.
- Very, very cheap, but slow.
- Useful for not much more than basic motion for text-editing tasks.
- No standardised layout, but inverted “T”, most common



# Discrete positioning controls

- in phones, TV controls etc.
  - cursor pads or mini-joysticks
  - discrete left-right, up-down
  - mainly for menu selection

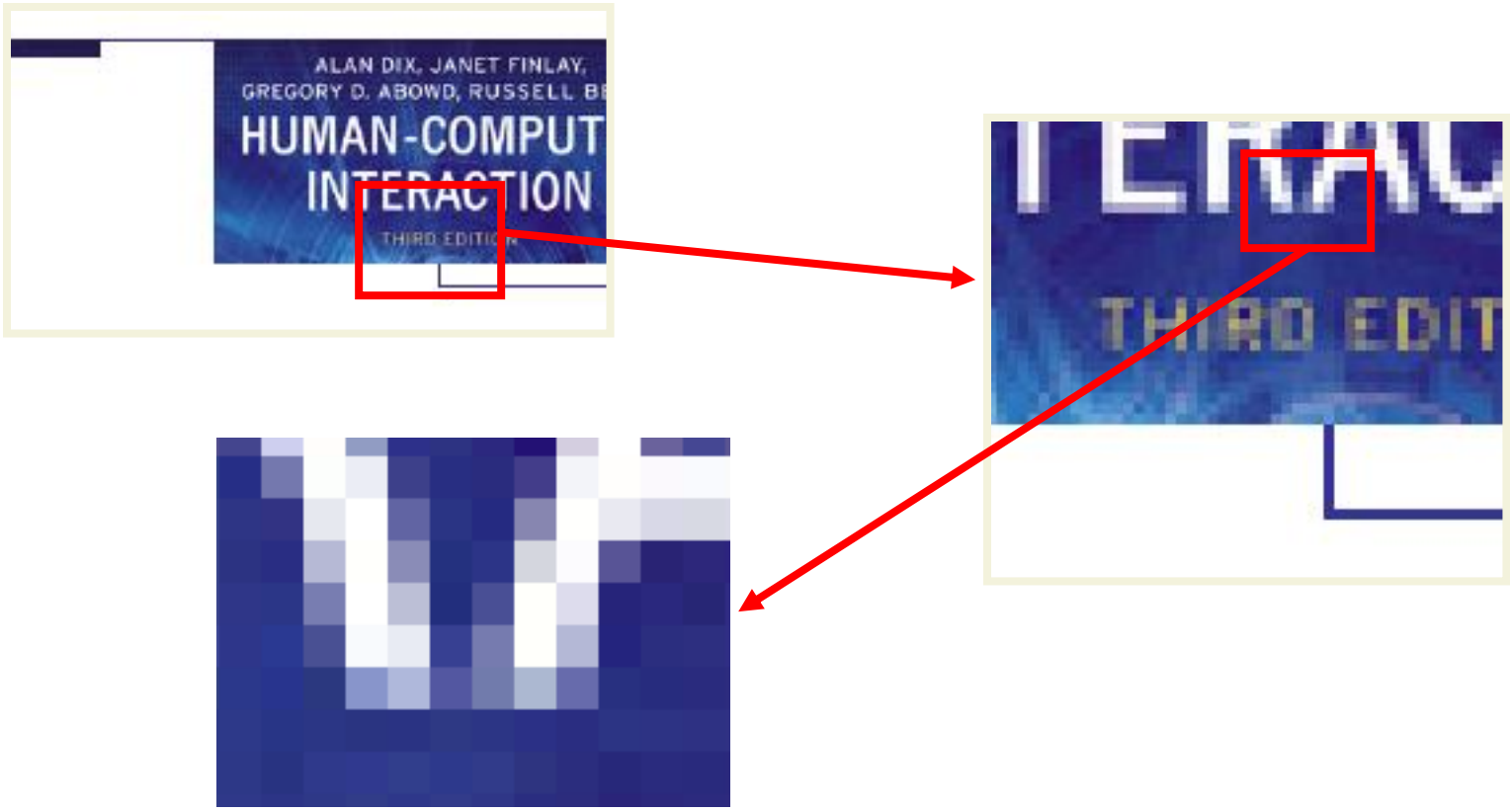
# DISPLAY DEVICES

bitmap screens (CRT & LCD)

large & situated displays
digital paper

# Bitmap displays

- screen is vast number of coloured dots

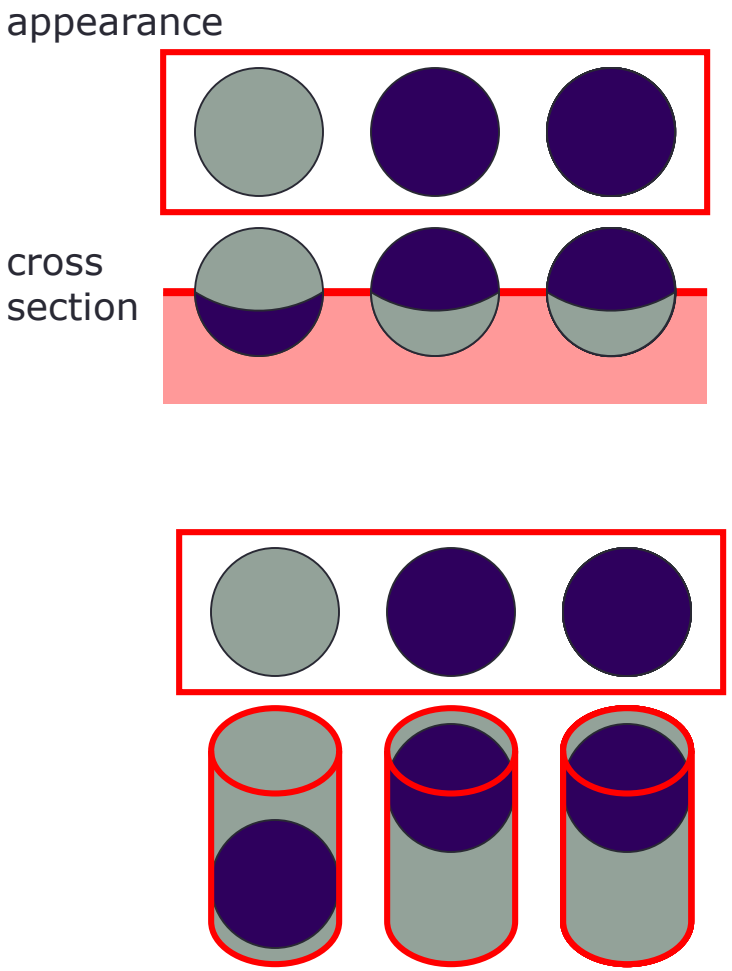


# Resolution and colour depth

- Resolution … used (inconsistently) for
  - number of pixels on screen (width x height)
    - e.g. SVGA 1024 x 768, PDA perhaps 240x400
  - density of pixels (in pixels or dots per inch - dpi)
    - typically between 72 and 96 dpi
- Aspect ratio
  - ration between width and height
  - 4:3 for most screens, 16:9 for wide-screen TV
- Colour depth:
  - how many different colours for each pixel?
  - black/white or greys only
  - 256 from a pallete
  - 8 bits each for red/green/blue = millions of colours

# Digital paper

- what?
  - thin flexible sheets
  - updated electronically
  - but retain display
- how?
  - small spheres turned
  - or channels with coloured liquid and contrasting spheres
  - rapidly developing area



# VIRTUAL REALITY AND 3D INTERACTION

positioning in 3D space
moving and grasping
seeing 3D (helmets and caves)

# Positioning in 3D space

- cockpit and virtual controls
  - steering wheels, knobs and dials … just like real!
- the 3D mouse
  - six-degrees of movement: x, y, z + roll, pitch, yaw
- data glove
  - fibre optics used to detect finger position
- VR helmets
  - detect head motion and possibly eye gaze
- whole body tracking
  - accelerometers strapped to limbs or reflective dots and video processing

# PAPER: PRINTING AND SCANNING

print technology

fonts, page description, WYSIWYG

scanning, OCR

# Printing

- image made from small dots
  - allows any character set or graphic to be printed,
- critical features:
  - resolution
    - size and spacing of the dots
    - measured in dots per inch (dpi)
  - speed
    - usually measured in pages per minute
  - cost!!

# Types of dot-based printers

- dot-matrix printers
  - use inked ribbon (like a typewriter
  - line of pins that can strike the ribbon, dotting the paper.
  - typical resolution 80-120 dpi
- ink-jet and bubble-jet printers
  - tiny blobs of ink sent from print head to paper
  - typically 300 dpi or better .
- laser printer
  - like photocopier: dots of electrostatic charge deposited on drum, which picks up toner (black powder form of ink) rolled onto paper which is then fixed with heat
  - typically 600 dpi or better.

# Printing in the workplace

- shop tills
  - dot matrix
  - same print head used for several paper rolls
  - may also print cheques
- thermal printers
  - special heat-sensitive paper
  - paper heated by pins makes a dot
  - poor quality, but simple & low maintenance
  - used in some fax machines

# Fonts

- Font – the particular style of text

Courier font
Helvetica font
Palatino font
Times Roman font

- §´∝≡↵ℑ ⊗↵~ (special symbol)

- Size of a font measured in points (1 pt about 1/72”) (vaguely) related to its height

This is ten point Helvetica
This is twelve point
This is fourteen point
This is eighteen point
and this is twenty-four point

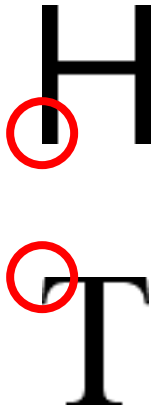
# Fonts

## Pitch

- fixed-pitch – every character has the same width
  e.g. `Courier`
- variable-pitched – some characters wider
  e.g. Times Roman – compare the ‘i’ and the “m”

## Serif or Sans-serif

- sans-serif – square-ended strokes
  e.g. Helvetica
- serif – with splayed ends (such as)
  e.g. Times Roman or Palatino



# Readability of text

- lowercase
  - easy to read shape of words
- UPPERCASE
  - better for individual letters and non-words
    e.g. flight numbers: BA793 vs. ba793
- serif fonts
  - helps your eye on long lines of printed text
  - but sans serif often better on screen

# Scanners

- Take paper and convert it into a bitmap
- Two sorts of scanner
  - flat-bed: paper placed on a glass plate, whole page converted into bitmap
  - hand-held: scanner passed over paper, digitising strip typically 3-4” wide
- Shines light at paper and note intensity of reflection
  - colour or greyscale
- Typical resolutions from 600–2400 dpi

# Scanners

Used in

- desktop publishing for incorporating photographs and other images
- document storage and retrieval systems, doing away with paper storage
- special scanners for slides and photographic negatives

# MEMORY

short term and long term

speed, capacity, compression

formats, access

# Short-term Memory - RAM

- Random access memory (RAM)
  - on silicon chips
  - 100 nano-second access time
  - usually volatile (lose information if power turned off)
  - data transferred at around 100 Mbytes/sec
- Some *non-volatile RAM* used to store basic set-up information
- Typical desktop computers:
  64 to 256 Mbytes RAM

# Long-term Memory - disks

- magnetic disks
  - floppy disks store around 1.4 Mbytes
  - hard disks typically 40 Gbytes to 100s of Gbytes
    access time ~10ms, transfer rate 100kbytes/s

- optical disks
  - use lasers to read and sometimes write
  - more robust that magnetic media
  - CD-ROM
    - same technology as home audio, ~ 600 Gbytes
  - DVD - for AV applications, or very large files