BIT 2nd Year
Semester 3
IT 3405

User Interface Design
Chapter 2 - Understanding the Human User

INTENDED LEARNING OUTCOMES

- Recognize how human communicates through different channels and reactions with a computer
- Identify how information is stored and processed in human memory
- Describe human thinking process to solve problems
- Analyze different user populations with respect to different their abilities and characteristics when using computers
- Explain human capabilities and limitations that have direct impact on the interface design

SUB TOPICS

2.1. Different Channels and how human process data

2.2. Human Memory Management

2.3. Human Thinking and Problem solving

2.4. Human errors when using computers

2.5. Types of Users

2.1. DIFFERENT CHANNELS AND HOW HUMAN PROCESS DATA

The Human user

Humans are limited in their capacity to process information. This has important implications for design.

Understanding the user

A Human can be viewed as an information processing system.

- Information received and responses given via input-output channels
  - visual, auditory, haptic, movement
- Information stored in memory
  - sensory, short- term, long –term
- Information processed and applied in various ways
  - reasoning, problem solving, skill, error

Different Channels and how human process data

- Information Processing & Human [Human Processor Model]
- Input/output Channels
  - INPUT:
    - visual (sight), auditory (hearing), haptic (touch)
    - Taste and Smell
  - OUTPUT:
    - Auditory (speaking)
    - Body (movement, appearance)

Active Channels and communicate the status

- Input in the human occurs mainly through the senses and output through the motor control of the effectors.
- There are five major senses: **sight, hearing, touch, taste** and **smell.**
- Of these**, the first three are the most important** to HCI.
- Taste and smell do not currently play a significant role in interface design. (It is possible future applications may exploit these senses)
- Speaking, Body movement, Facial expressions, etc. are used to output the status of human process

Different Channels in computers and human users

Input Vs. Output

- Entering data/information into computers
  - Keyboard – Character processing - Text data
  - Speakers - Voice Recognition – Audio data
  - Camera - Image Recognition (Computer Vision) – Image data
  - Mouse – Spatial processing - point of location
- Entering data/information into human user
  - Eyes - …..
  - Ears - ……
  - Body - ……..
- Output data/information
  - The most common method is by viewing information expressed as text, an image or video displayed on a screen.
  - Auditory data may take the form of music, recorded of speech, text-to-speech or alert sounds.

Components of human process

Storing (in memory)

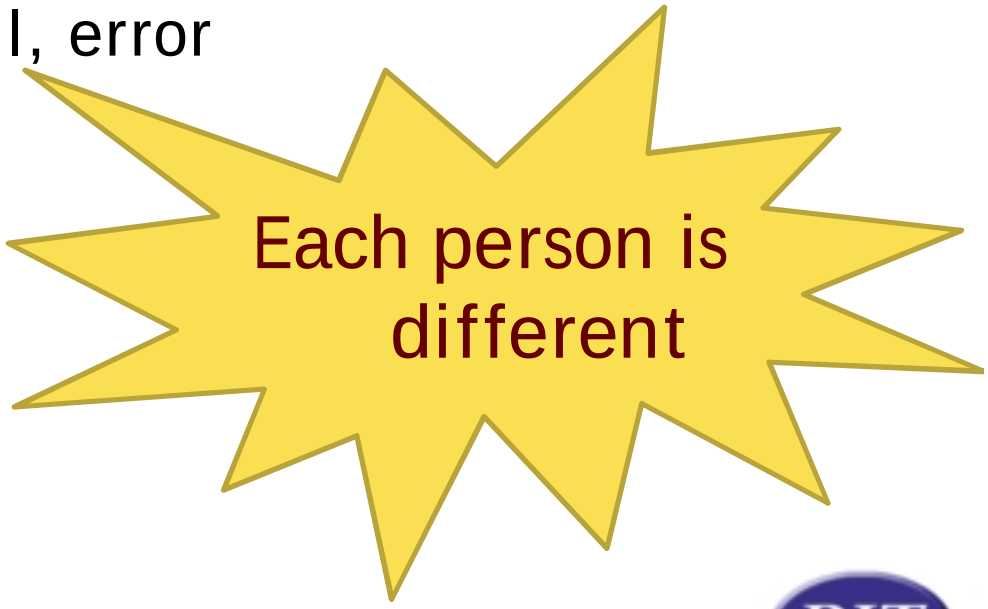
- Types: sensory, short-term, long-term

Methods

- reasoning, problem solving

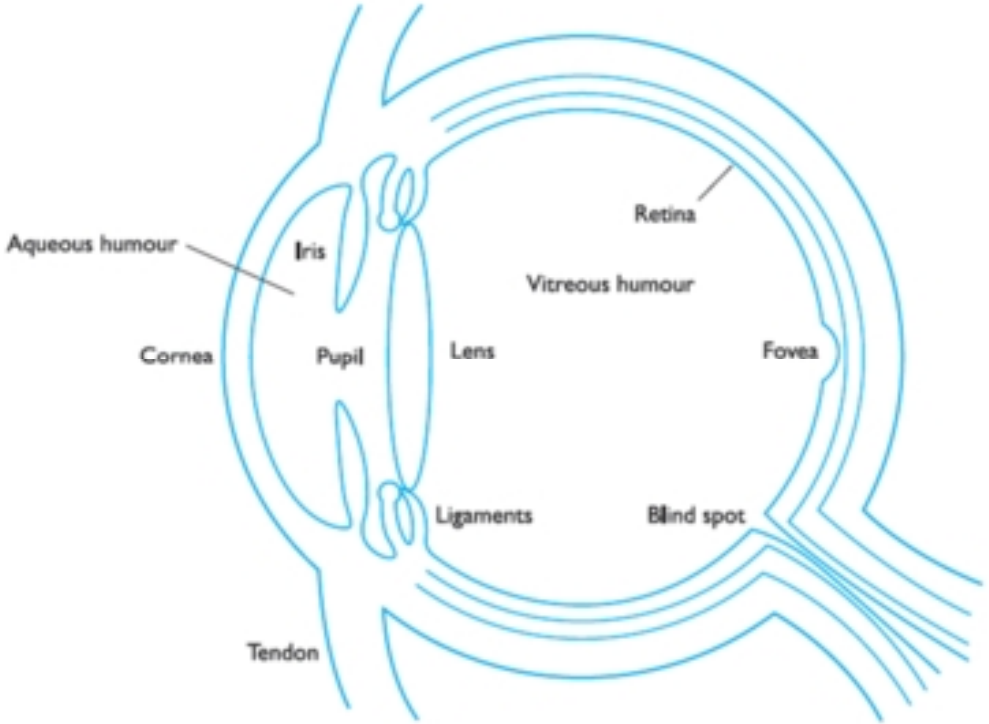
Power (human capabilities)

- Emotion influences, skill, error



Human Eye

- Capabilities of humans in receiving information may vary from one to another although all humans have same eye structure (individual differences)
- “What you see” Vs “What you understand”.



Interpreting the visual signal

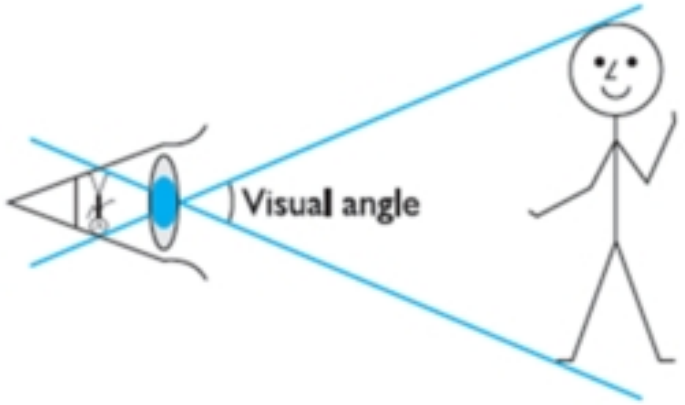
Size and depth

- *visual angle* indicates how much of view object occupies (relates to size and distance from eye)

Perceiving size and depth

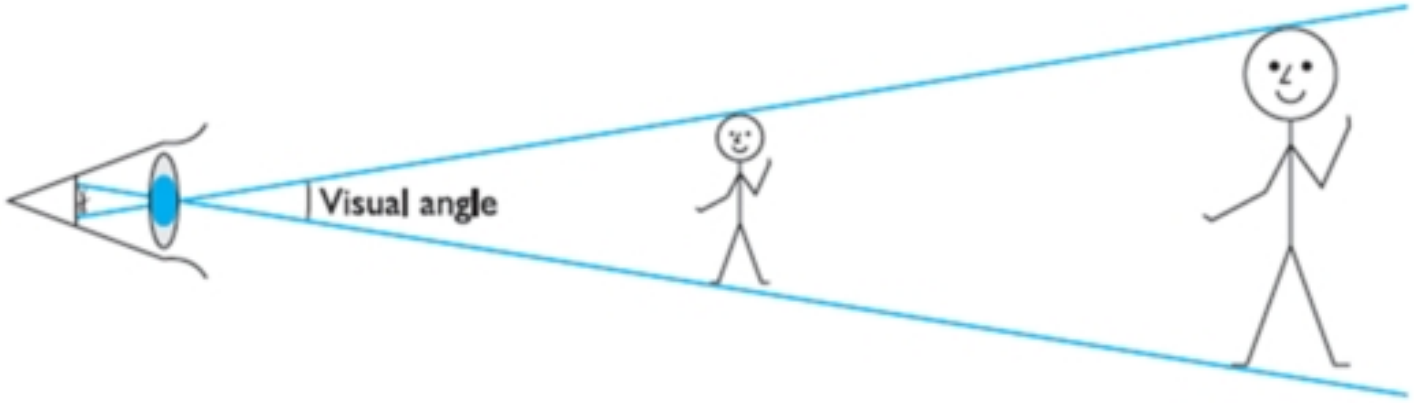
- Imagine you are standing on a hilltop. Beside you on the summit you can see rocks, sheep and a small tree. On the hillside is a farmhouse with outbuildings and farm vehicles. Someone is on the track, walking toward the summit. Below in the valley is a small market town. Even in describing such a scene the notions of size and distance predominate. Our visual system is easily able to interpret the images which it receives to take account of these things. We can identify similar objects regardless of the fact that they appear to us to be of vastly different sizes. In fact, we can use this information to judge distances.

Visual Angles Vs Object Size



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



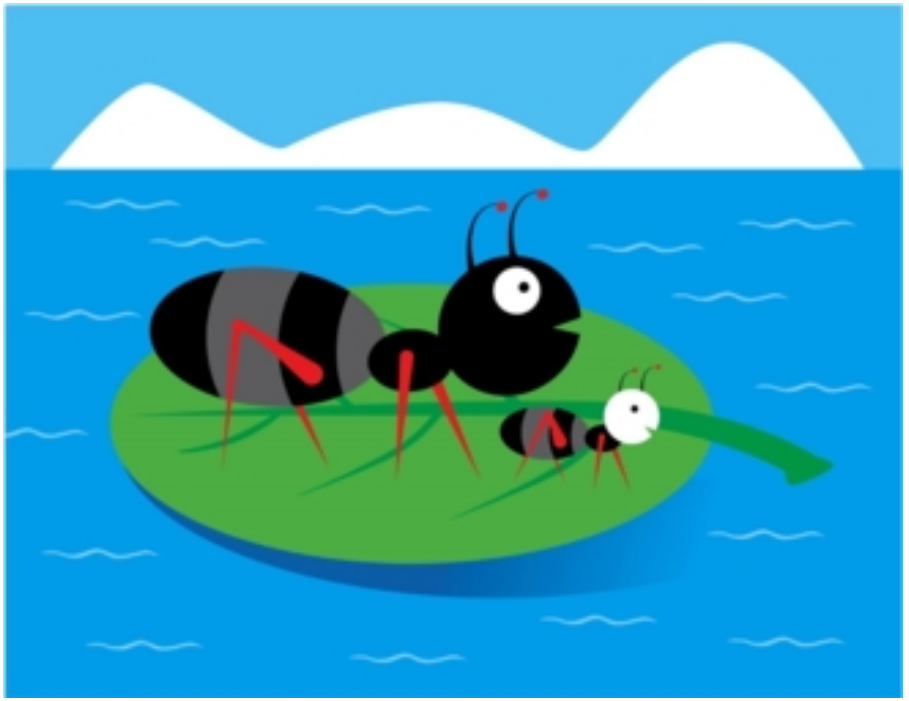
Interpreting the signal to identify objects

- So how does the eye perceive size, depth and relative distances? To understand this we must consider how the image appears on the retina. As we noted in the previous slide, reflected light from the object forms an upside-down image on the retina.

- The size of that image is specified as a *visual angle*. If we were to draw a line from the top of the object to a central point on the front of the eye and a second line from the bottom of the object to the same point, the visual angle of the object is the angle between these two lines.

Identifying the larger objects

- Visual angle is affected by both the size of the object and its distance from the eye. Therefore if two objects are at the same distance, the larger one will have the larger visual angle.

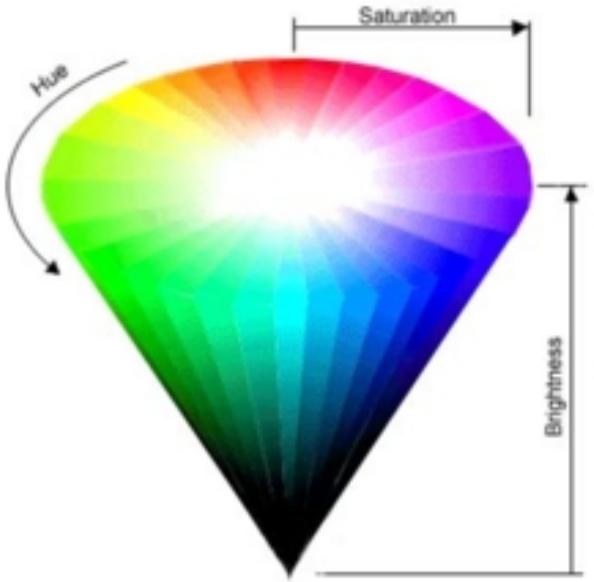


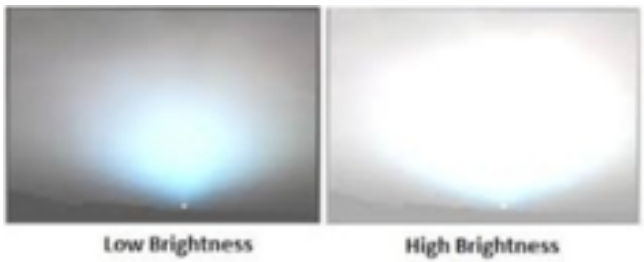
Visual Acuity

- visual acuity is ability to perceive detail (limited)
- familiar objects perceived as constant size
  (in spite of changes in visual angle when far away)
- overlapping help perception of size and depth

Brightness

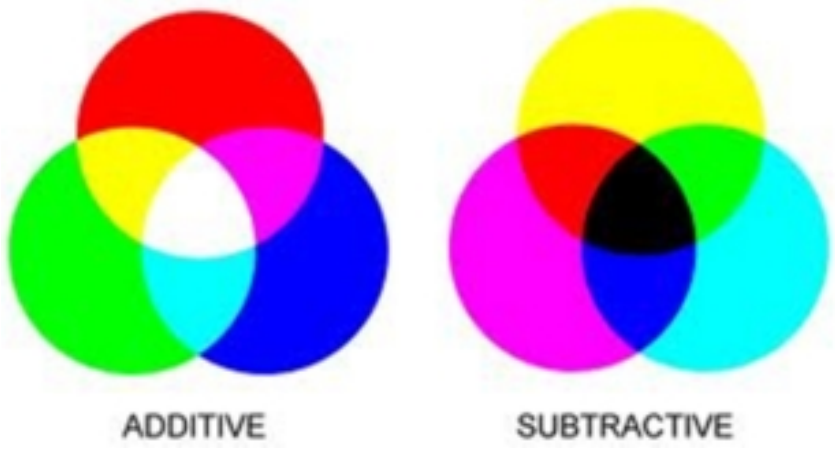
- subjective reaction to levels of light
- affected by luminance of object
- measured by just noticeable difference
- visual acuity increases with luminance as does flicker





Colour

- made up of hue, intensity, saturation
- cones sensitive to colour wavelengths
- blue acuity is lowest
- 8% males and 1% females colour blind



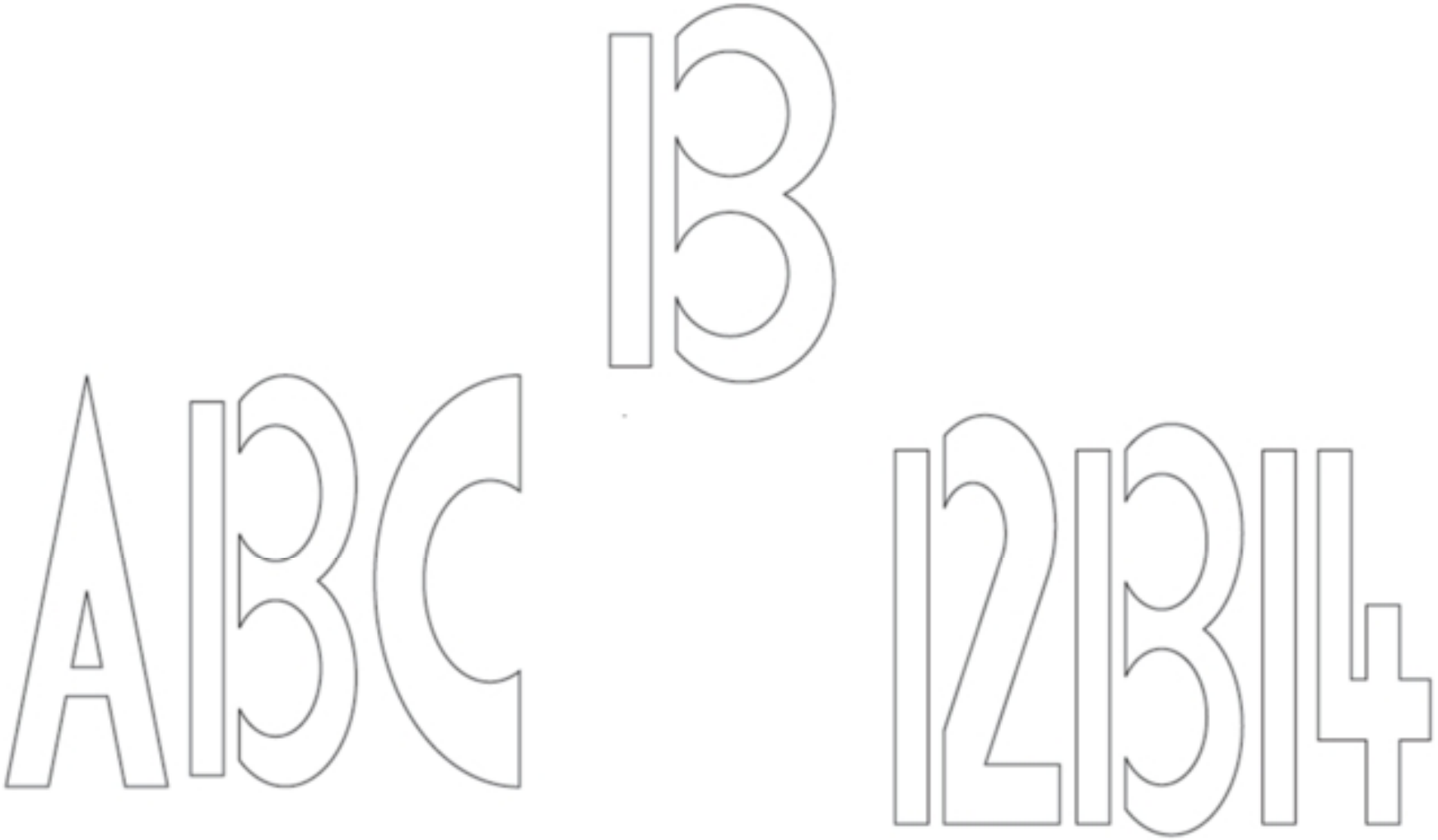
Movement and Luminance

The visual system compensates for:

- Movement
- changes in luminance

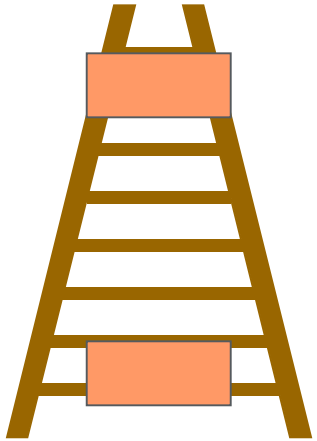
How do you read the name board of moving bus?

Context is used to resolve ambiguity

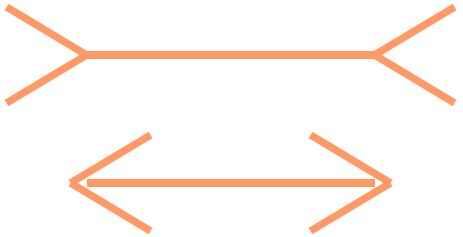


Optical Illusions

- Optical illusions sometimes occur due to over compensation.
- An optical illusion (also called a visual illusion) is characterized by visually perceived images that differ from objective reality. The information gathered by the eye is processed and the brain to give a percept that does not tally with a physical measurement of the stimulus source.



the Ponzo illusion

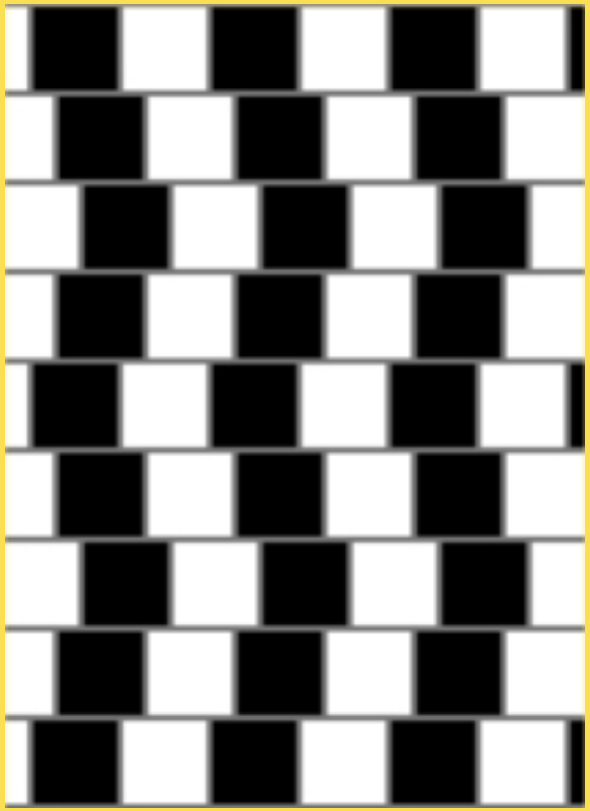


the Muller Lyer illusion

Optical Illusions (See carefully)

Wife or Mother-in-Law

Optical Illusions Cont...



Can you READ with mistakes ?

THE PAOMNNEHAL 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, the olny iprmoatnt tihng is taht the frist and lsat ltteer be in the rghit pclae. The rset can be a taotl mses and you can sitll raed it wouthit porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe.

How do we really Read?

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 (dark characters on a light screen) improves reading from computer screen.

(**black letters on white space**)

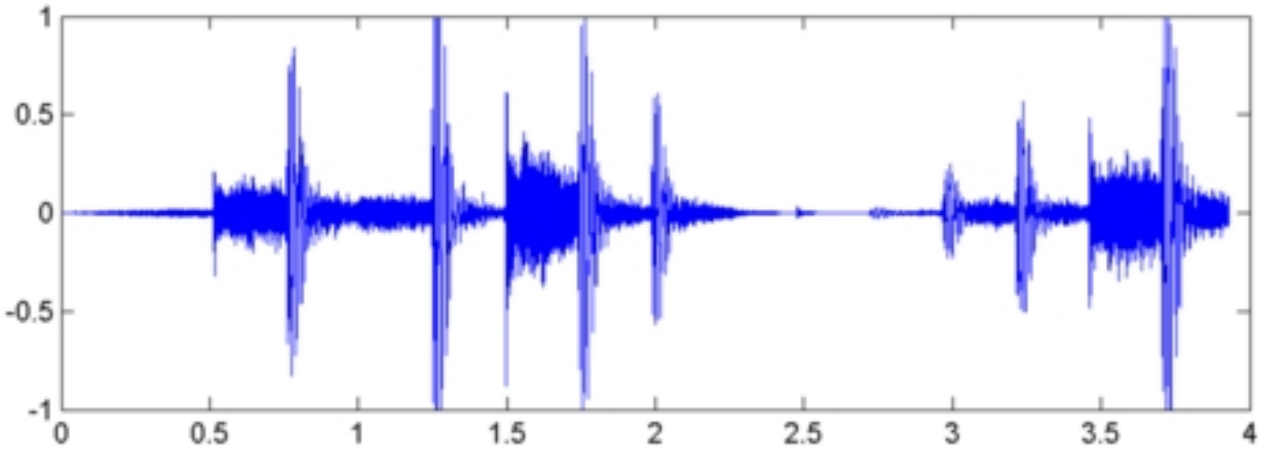
Hearing

- Provides information about environment:
  you recognize distances, directions, objects
  with the sound

- 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

Interpreting sound

- Humans can hear frequencies from 20Hz to 20kHz
  - less accurate distinguishing high frequencies than low.
- Auditory system filters sounds
  - can attend to sounds over background noise.
  - for example, the cocktail party phenomenon.



Uses of non-speech sounds

- **Attention** – to attract the user's attention to a critical situation or to the end of a process.
- **Status information** – continuous background sounds can be used to convey status information. For example, monitoring the progress of a process (without the need for visual attention).
- **Confirmation** – a sound associated with an action to confirm that the action has been carried out. For example, associating a sound with deleting a file.
- **Navigation** – using changing sound to indicate where the user is in a system. For example, what about sound to support navigation in hypertext?

Touch

- Provides important feedback about environment.
- May be key sense for someone who is visually impaired.
- 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*.
- Kinethesis - awareness of body position
  - affects comfort and performance.

Movement

- Time taken to respond to stimulus:
  reaction time + movement time
  - E.g. distance between two moving vehicles
- Movement time dependent on age, fitness etc. (User dependent variable)
- 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.

Hint for Design:
If you want to inform something quickly, you have to use audio based interaction. It is faster than visual interaction.

Fitts Law in Visual Design

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

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

where: a and b are empirically determined constants

Mt = movement time

D = Distance

S = Size of target

- Hint for Design:

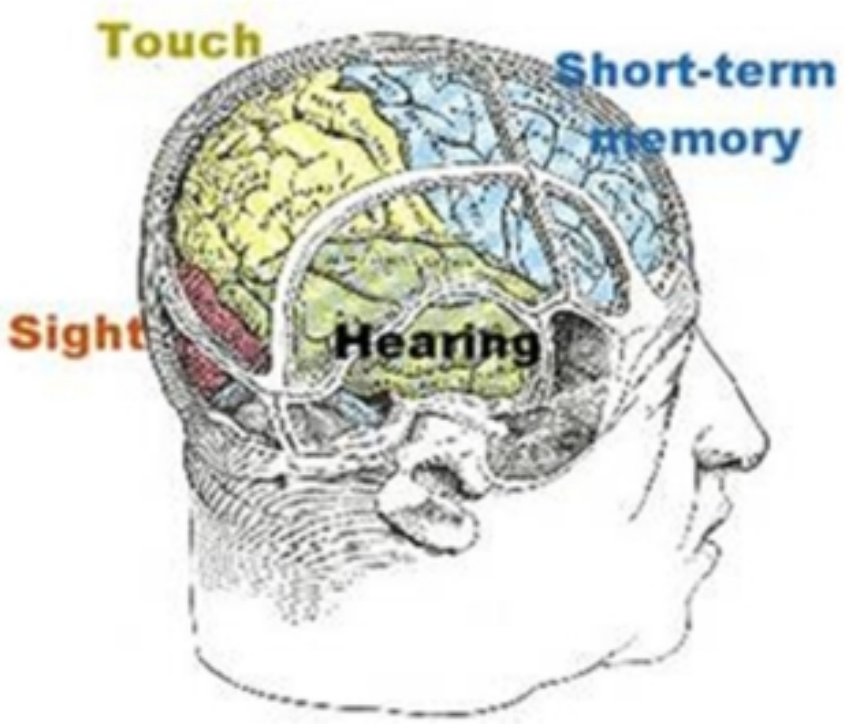
targets as large as possible

distances as small as possible

2.2.
HUMAN MEMORY MANAGEMENT

Human Memory Management

- Sensory Memory
- Short Term Memory
- Long Term Memory



Propagation in the 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

There are things that you can easily remember

There are things that you find hard to remember

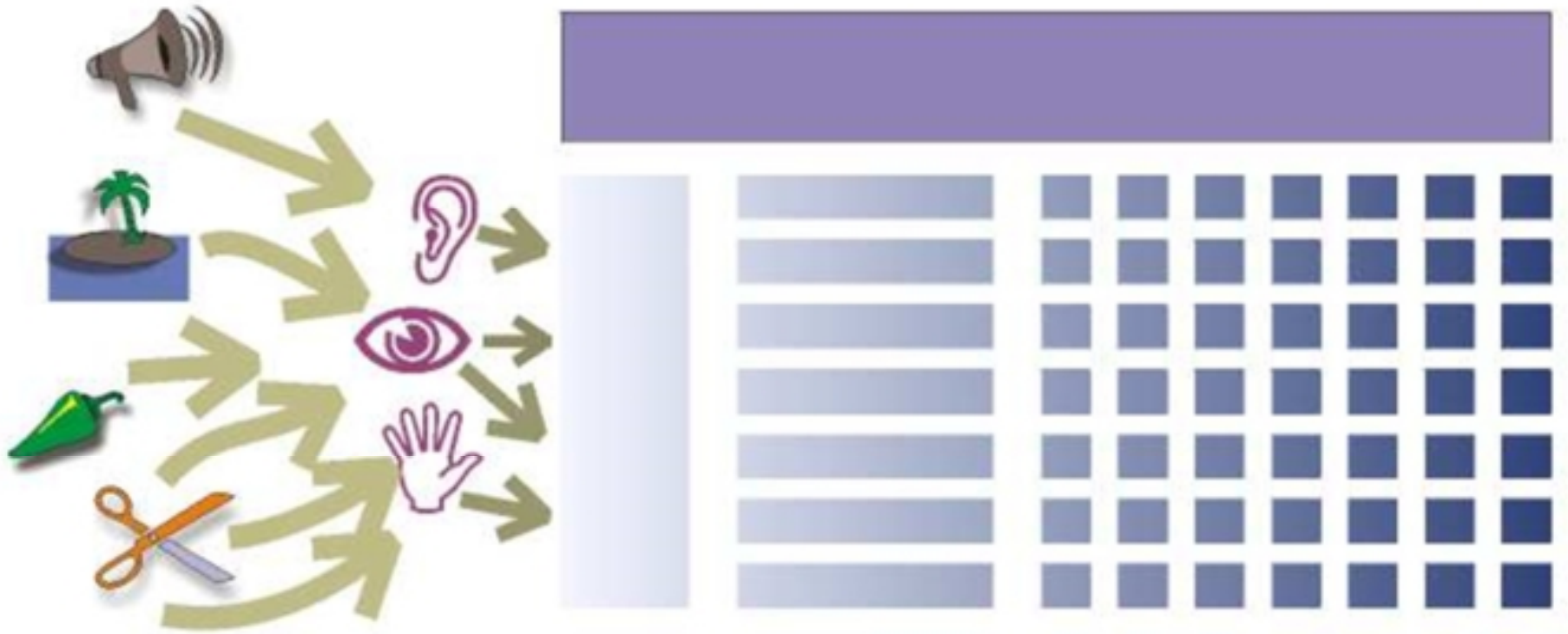
Memory Propagation

Memory Propagation

Real World

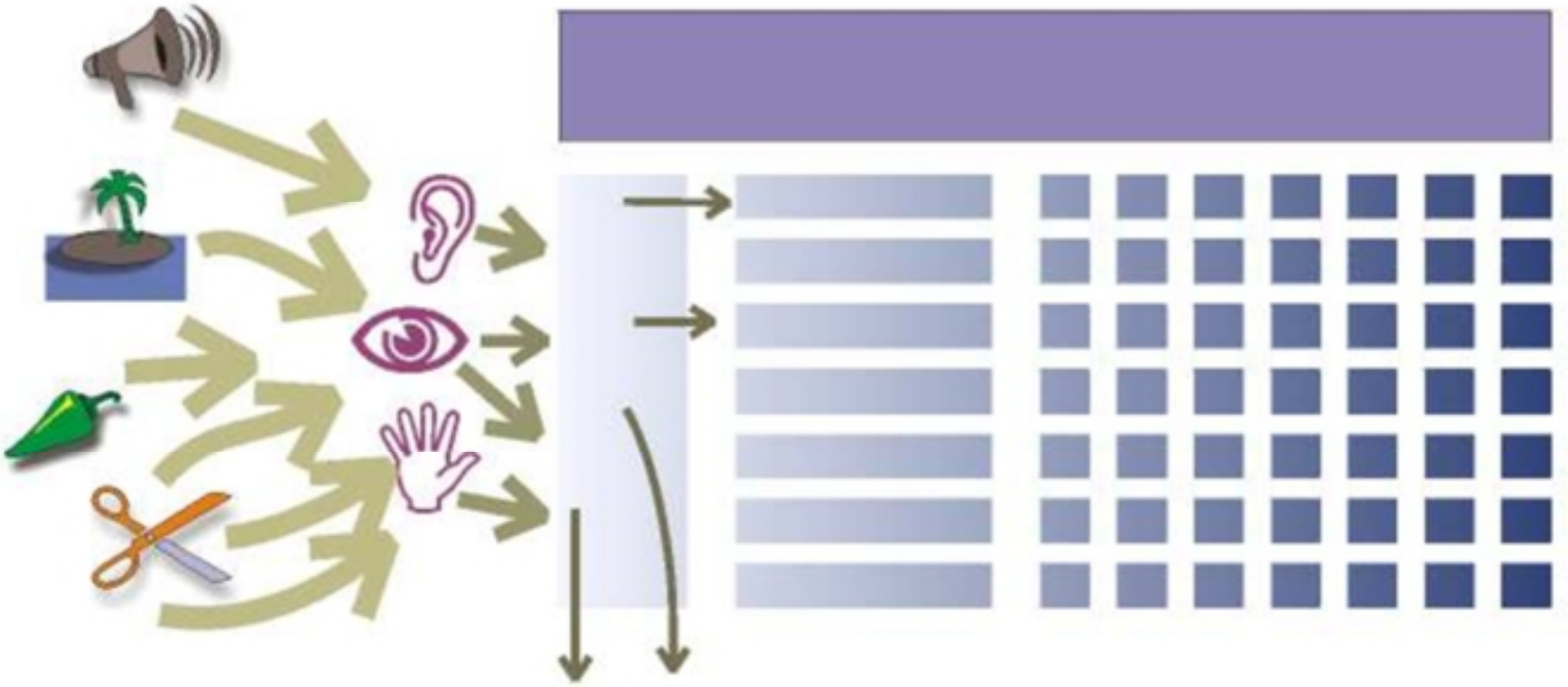
Sense Organs

Memory Propagation



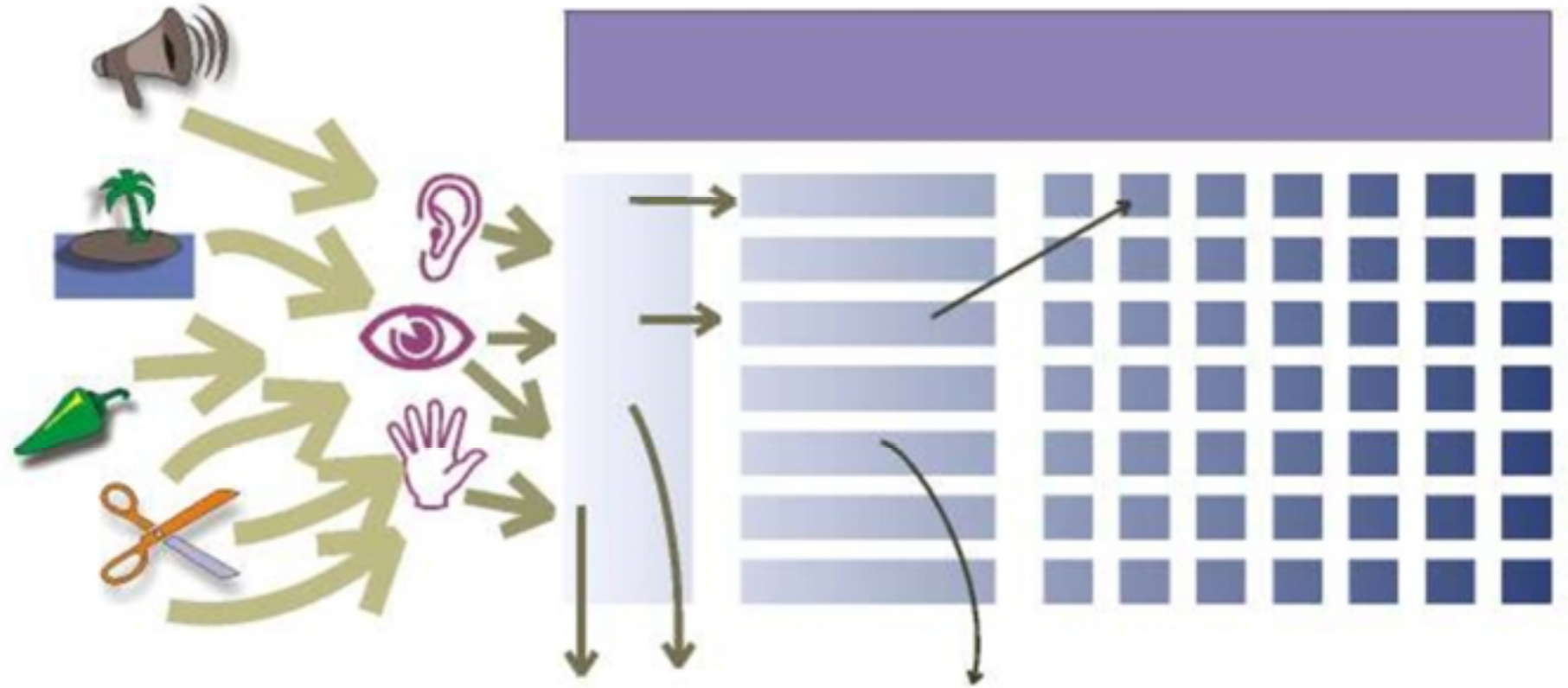
Real World | Sense Organs | Sensory Buffer

Memory Propagation



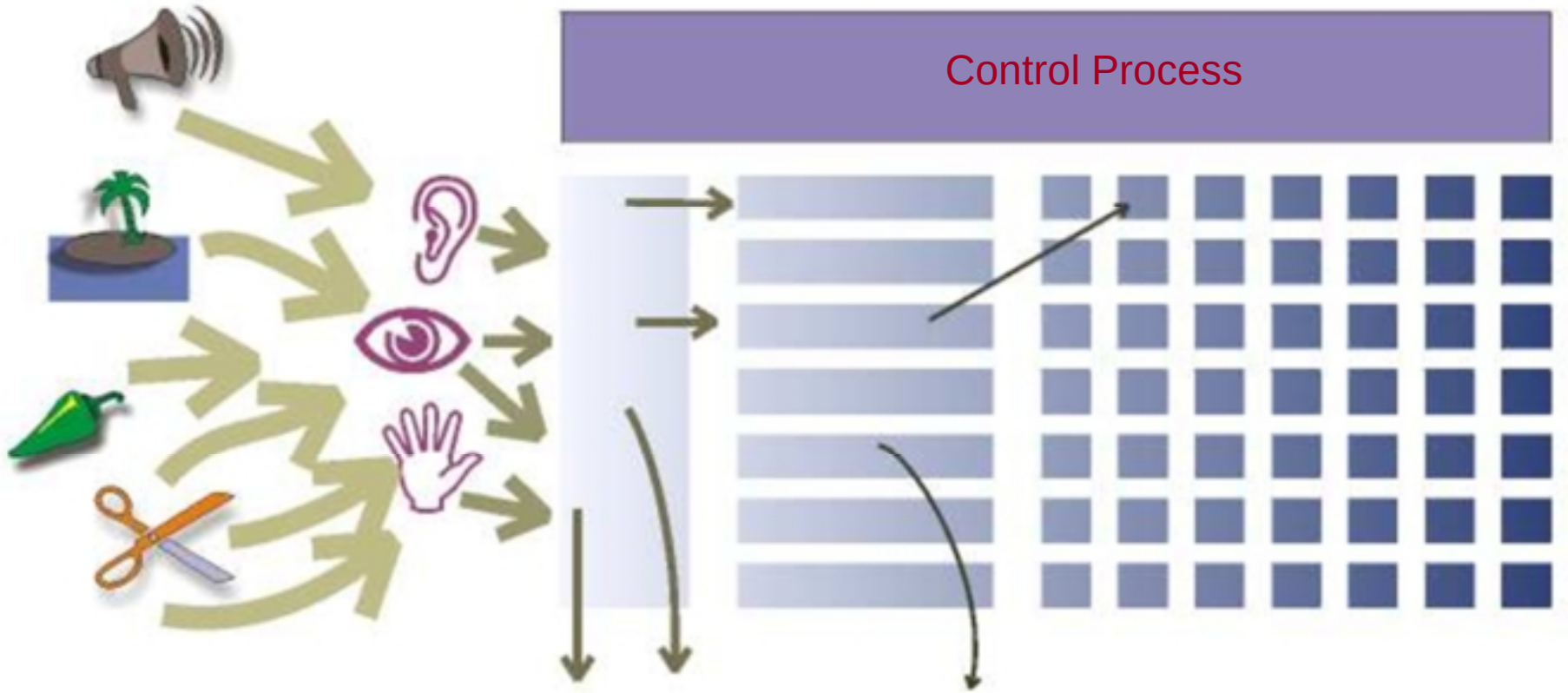
Real World | Sense Organs | Sensory Buffer | Short Term Memory

Memory Propagation



Real World | Sense Organs | Sensory Buffer | Short Term Memory | Long Term Memory

Memory Propagation



Sensory memory

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

Short-term memory (STM)

- Scratch-pad for temporary recall
- Info retained automatically and kept in place by rehearsal
  - rapid access ~ 70ms
- Always and easily retrieved
  - rapid decay ~ 200ms
- Quickly and easily lost, unless processed continuously
- Severely limited amount of info 5-9 ‘items’
  - **limited capacity - 7± 2 chunks**

Examples: Memory of Arbitrary Things

212348278493202

0121 414 2626

HEC ATR ANU PTH ETR EET

Find the pattern

Long-term memory (LTM)

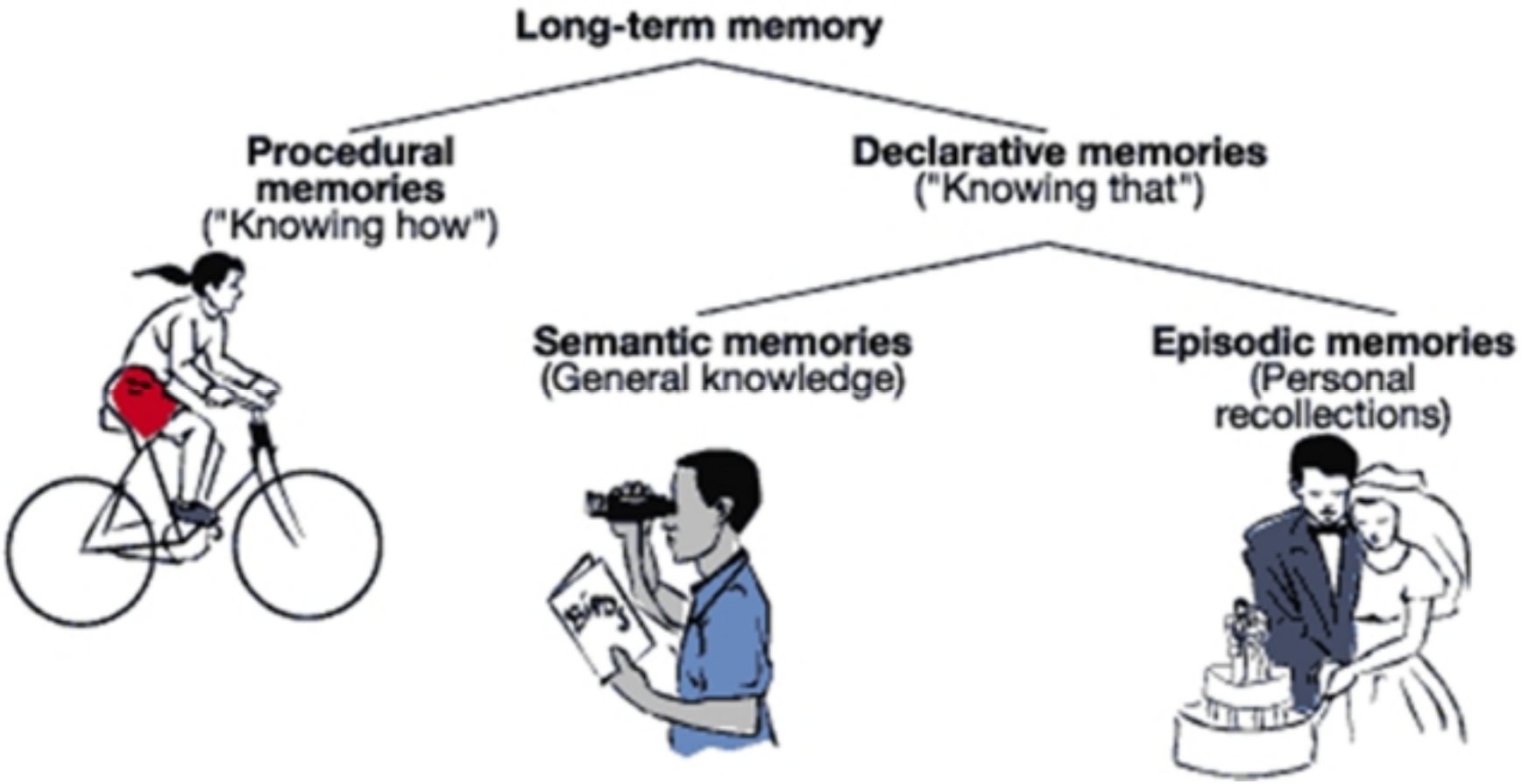
- Memory of the past
- Repository for all our knowledge
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge or unlimited capacity
- Problem is retrieval, not storage
- Two types
  - episodic – serial memory of events
  - semantic – structured memory of facts,concepts, skills

Semantic LTM derived from episodic LTM

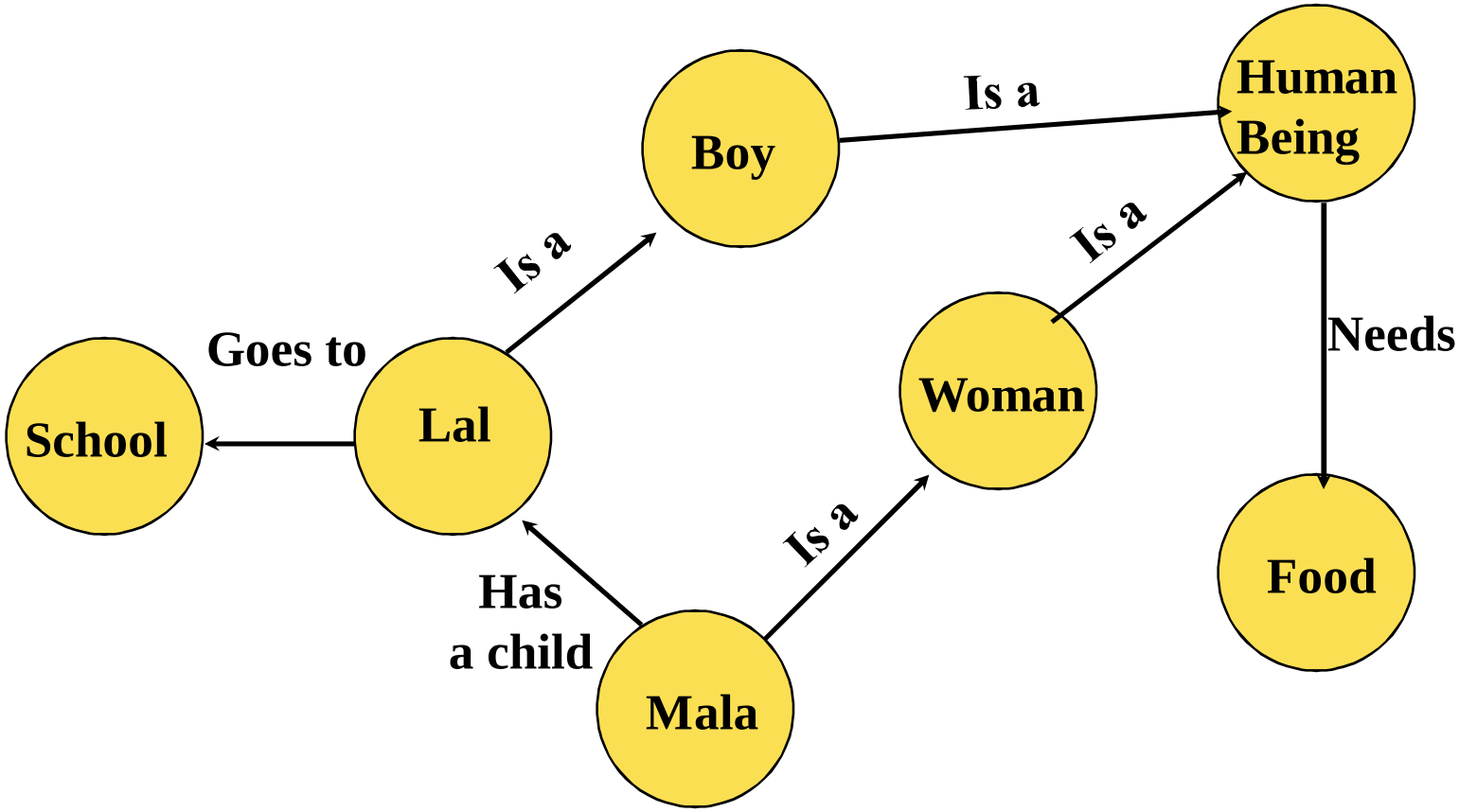
Long-term memory cont...

- 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

Long-term memory cont...



Example: Semantic Network



Inheritance: Mala is a woman, woman is a human being, human beings need food. Therefore, Mala needs food.

Models of LTM - Production rules

- Representation of procedural knowledge.
- Condition/action rules

  if condition is matched

  then use rule to determine action

IF dog is wagging tail
THEN pat dog

IF dog is growling
THEN run away

LTM - Storage of information

- rehearsal
  - information moves from STM to LTM
- total time hypothesis
  - amount retained proportional to rehearsal time
- distribution of practice effect
  - optimized by spreading learning over time
- structure, meaning and familiarity
  - information easier to remember

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

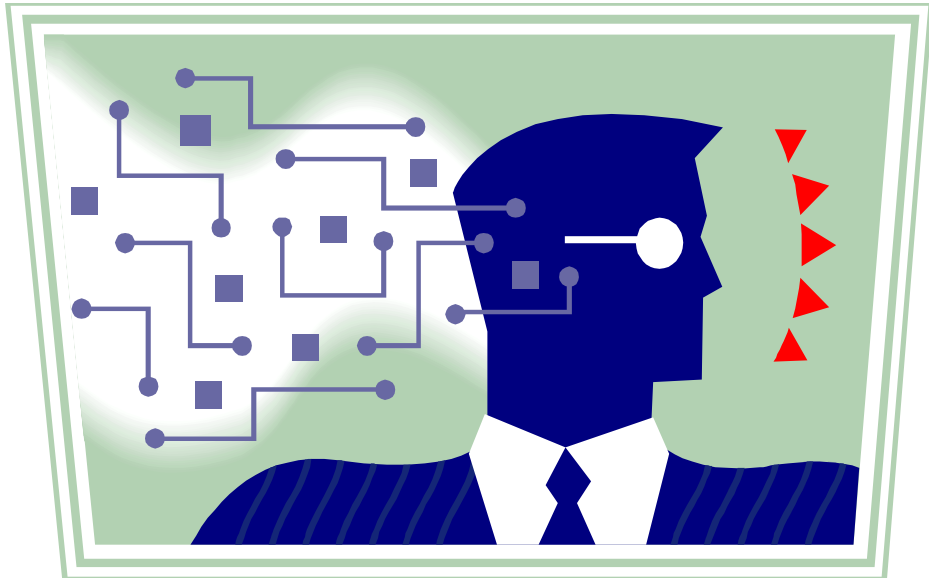
LTM - Retrieval

- 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

2.3. HUMAN THINKING AND PROBLEM SOLVING

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 cont….

- When truth and logical validity clash …

  e.g. Some people are babies

  Some babies cry

  Inference - Some people cry

  Is this 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.

    They have big ears like feathers but they cannot fly!!!

Do you know Dumbo?

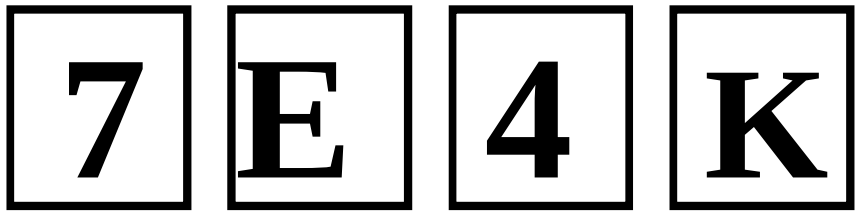
Inductive Reasoning

- Unreliable:
  - can only prove false not true

  ... but useful!

- Humans not good at using negative evidence

  e.g. Wason's cards.



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

Is this true?

How many cards do you need to turn over to find out?

.... and which cards?

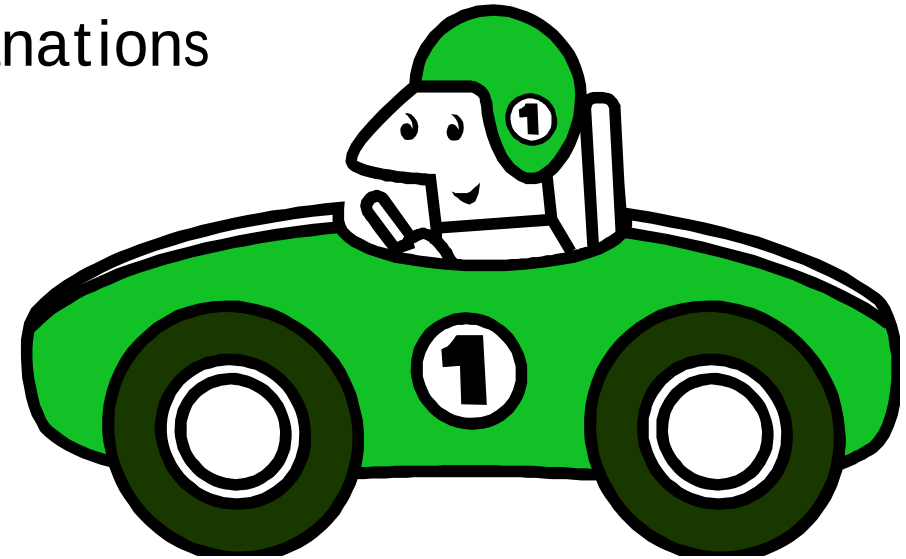
Abductive reasoning

- 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



Problem solving

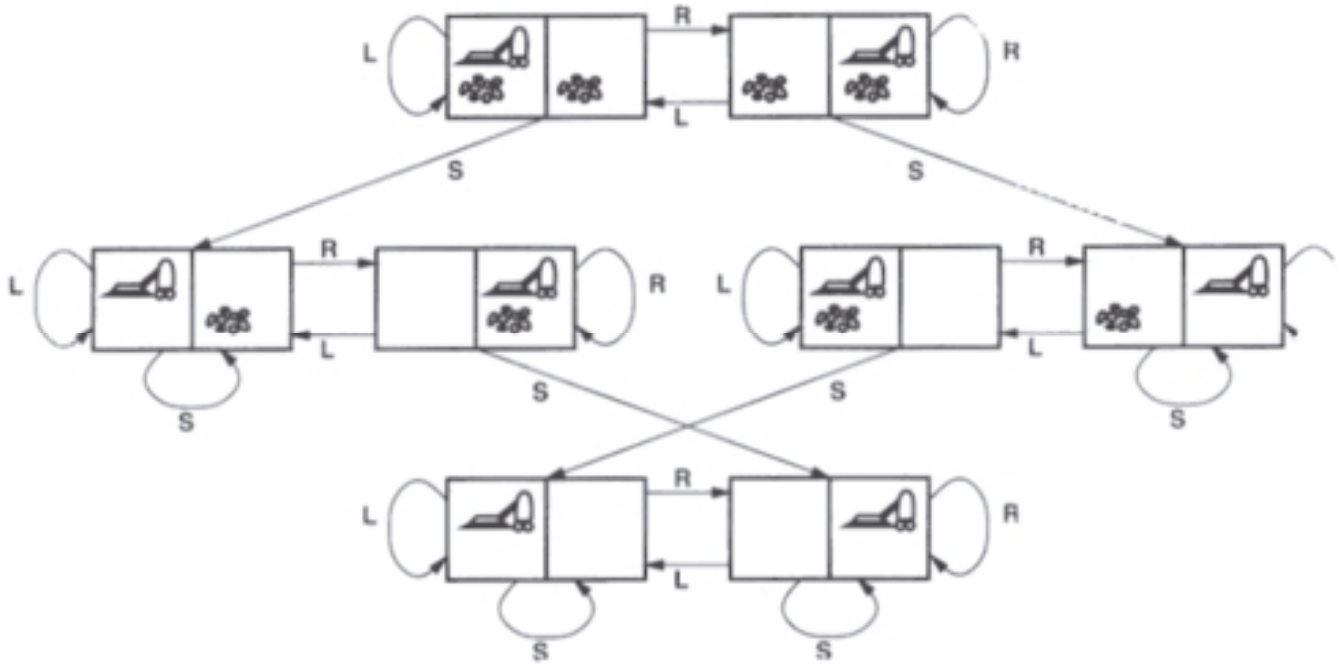
- Process of finding solution to unfamiliar task using knowledge
- Several theories
- Gestalt
  - problem solving both productive and reproductive
  - Reproductive: applying previous experience in problem solving
    - Unable to see novel interpretations that lead to a solution
  - Productive: draws on insight and restructuring of problem
  - attractive but not enough evidence to explain `insight' etc.
  - move away from behaviourism and led towards information processing theories

Problem solving cont...

Problem space theory

- problem space comprises problem states
- problem solving involves generating states using legal operators
- heuristics may be employed to select operators
- 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 cont...



simplified vacuum state space. Arcs denote actions.

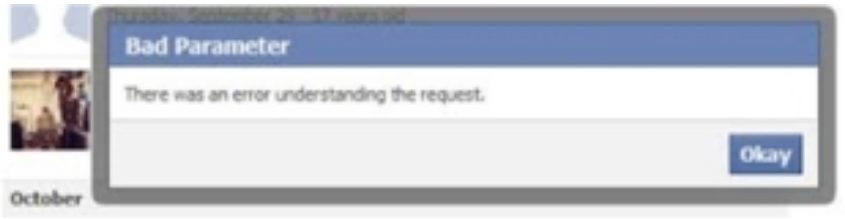
L = move left, R = move right, S = suck

- **States: one of the eight states shown in Figure**
- **Operators: move left, move right, suck.**
- **Goal test: no dirt left in any square**
- **Path cost: each action costs**

6.4.
HUMAN ERRORS WHEN USING COMPUTERS

Why errors are important

- Errors are unavoidable
  - To err is human
  - Making mistakes is part of the learning curve



Human error

- Human error is responsible for 60-90% of major accidents

- Factors contributed to human error
  - Failure to read the instructions
  - Inability to formulate an appropriate mental model
  - Failure of the plug designers to provide clear physical constraints on erroneous actions

Reference:

http://en.calidadpr.com/reducing%20human%20error%20QP.pdf

Human error Types - Slips

What is Slip?

- understand system and goal
- correct formulation of action
- incorrect action

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

Human error Types - Mistakes

mistake

may not even have right goal!

Fixing things?

- mistakes
  - wrong intention
  - cause: incorrect understanding
    - humans create mental models to explain behaviour
    - if wrong (different from actual system) errors can occur

Human error & Interface

How to minimize the human error when using computers?

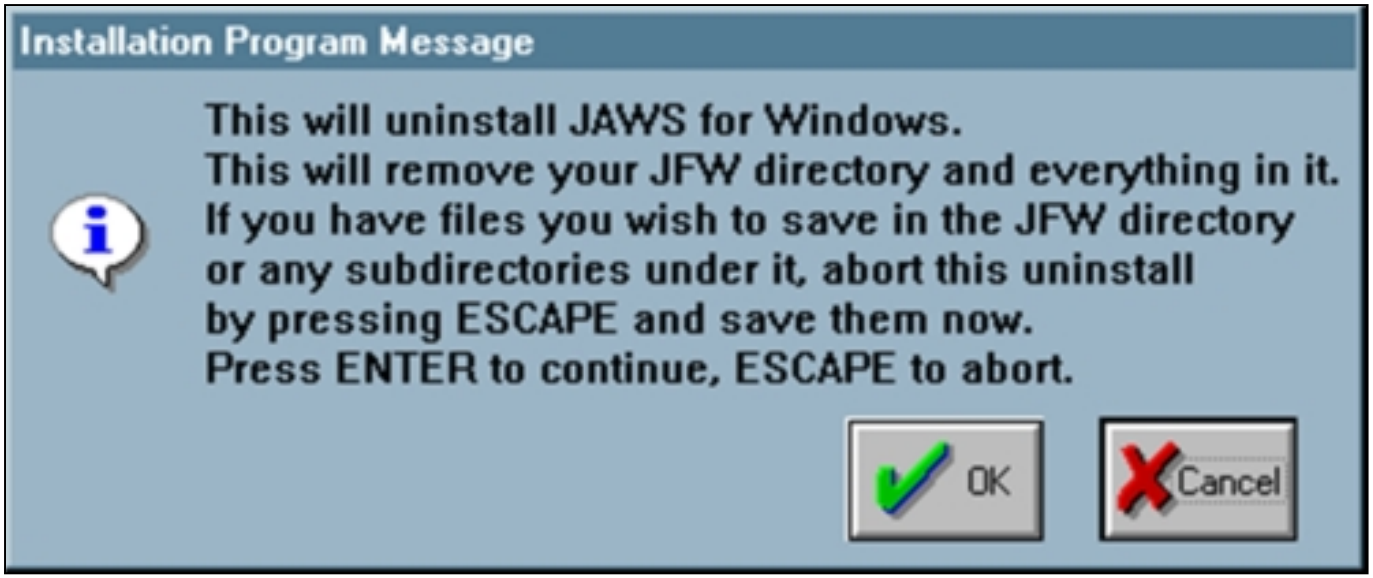
slips – better interface design

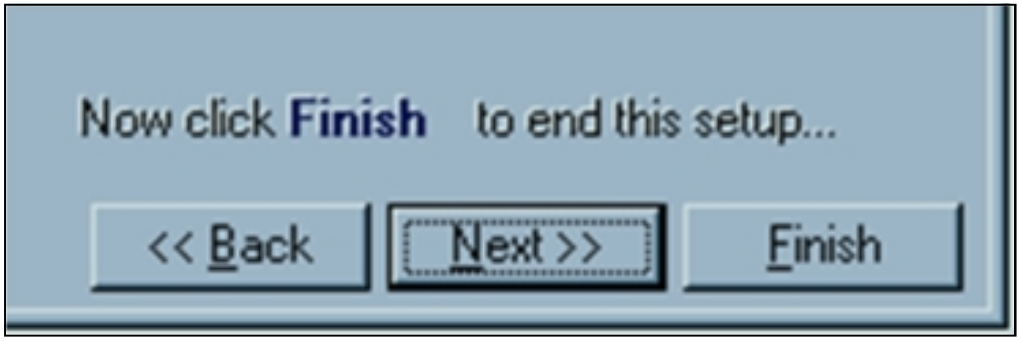
mistakes – better understanding of system

Interface Errors

- **Errors of Omission**
  - **– leaving out a step of the task or the whole task itself**
- **Error of Commission**
  - **– this involves several different types of error:**
    - **Errors of Selection**
      - ***– error in use of controls or in issuing of commands***
    - **Errors of Sequence**
      - ***– required action is carried out in the wrong order***
    - **Errors of Timing**
      - ***– task is executed before or after when required***
    - **Errors of Quantity**
      - ***– inadequate amount or in excess***

Great (Bad) Examples





2.5.
TYPES OF USERS

Individual differences

- long term
  - sex, physical and intellectual abilities
- short term
  - effect of stress or fatigue
- changing
  - age

Identify Users

- Who is a User?

It is necessary to think carefully about who is a user and how to involve users in the design process. Obviously users are the people who will use the final product or artifact to accomplish a task or goal. But there are other users as well.

The people who manage the users have needs and expectations too. What about those persons who are affected in some way by the use of the artifact or use the products and/or services of the artifact? Shouldn't their needs and expectations be taken into consideration in the design process?

User categories

- Types of Users
  - **Primary Users**
  - **Secondary Users**
  - **Tertiary Users**

The successful design of a product must take into account the wide range of stakeholders of the product. Not everyone who is a stakeholder needs to be represented on a design team, but the effect of the product on them must be considered.

Type of Users

- Primary users are those persons who actually use the product
- Secondary users are those who will occasionally use the product or those who use it through an intermediary
- Tertiary users are persons who will be affected by the use of the product or make decisions about its purchase.

Different users

- **Physical attributes**
  (age, gender, size, reach, visual angles, etc…)
- **Physical work places**
  (table height, sound levels, lighting, software version…)
- **Perceptual abilities**
  (hearing, vision, heat sensitivity…)
- **Cognitive abilities**
  (memory span, reading level, musical training, math…)
- **Personality and social traits**
  (likes, dislikes, preferences, patience…)
- **Cultural and international diversity**
  (languages, dialog box flow, symbols…)
- **Special populations, (dis)abilities**