



# HUMAN-COMPUTER INTERACTION

THIRD  
EDITION

DIX  
FINLAY  
ABOWD  
BEALE

## chapter 1

### the human

# the human

- Information is received and responses via number of i/o channels.
  - 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

# Vision

## Two stages in vision

- physical reception of stimulus
- processing and interpretation of stimulus

# 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

# Interpreting the signal

- Size and depth
  - visual angle indicates how much of view object occupies  
(relates to size and distance from eye)
  - visual acuity is ability to perceive detail  
(limited)
  - familiar objects perceived as constant size  
(in spite of changes in visual angle when far away)
  - cues like overlapping help perception of size and depth

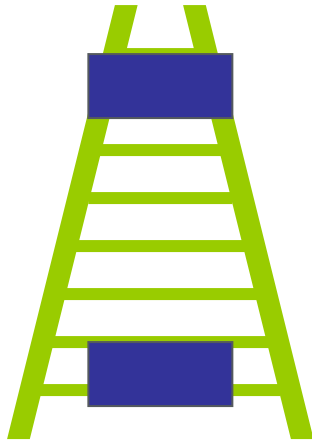
# Interpreting the signal (cont)

- 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

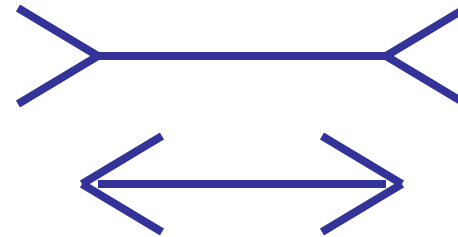
# Interpreting the signal (cont)

- The visual system compensates for:
  - movement
  - changes in luminance.
- Context is used to resolve ambiguity
- Optical illusions sometimes occur due to over compensation

# Optical Illusions



the Ponzo illusion



the Muller Lyer illusion



# 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

# 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 (cont)

- 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.

# 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
- 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 (cont)

- 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  $\sim 70\text{ms}$
  - rapid decay  $\sim 200\text{ms}$
  - limited capacity -  $7 \pm 2$  chunks

# Examples

212348278493202

0121 414 2626

HEC ATR ANU PTH ETR EET

# Long-term memory (LTM)

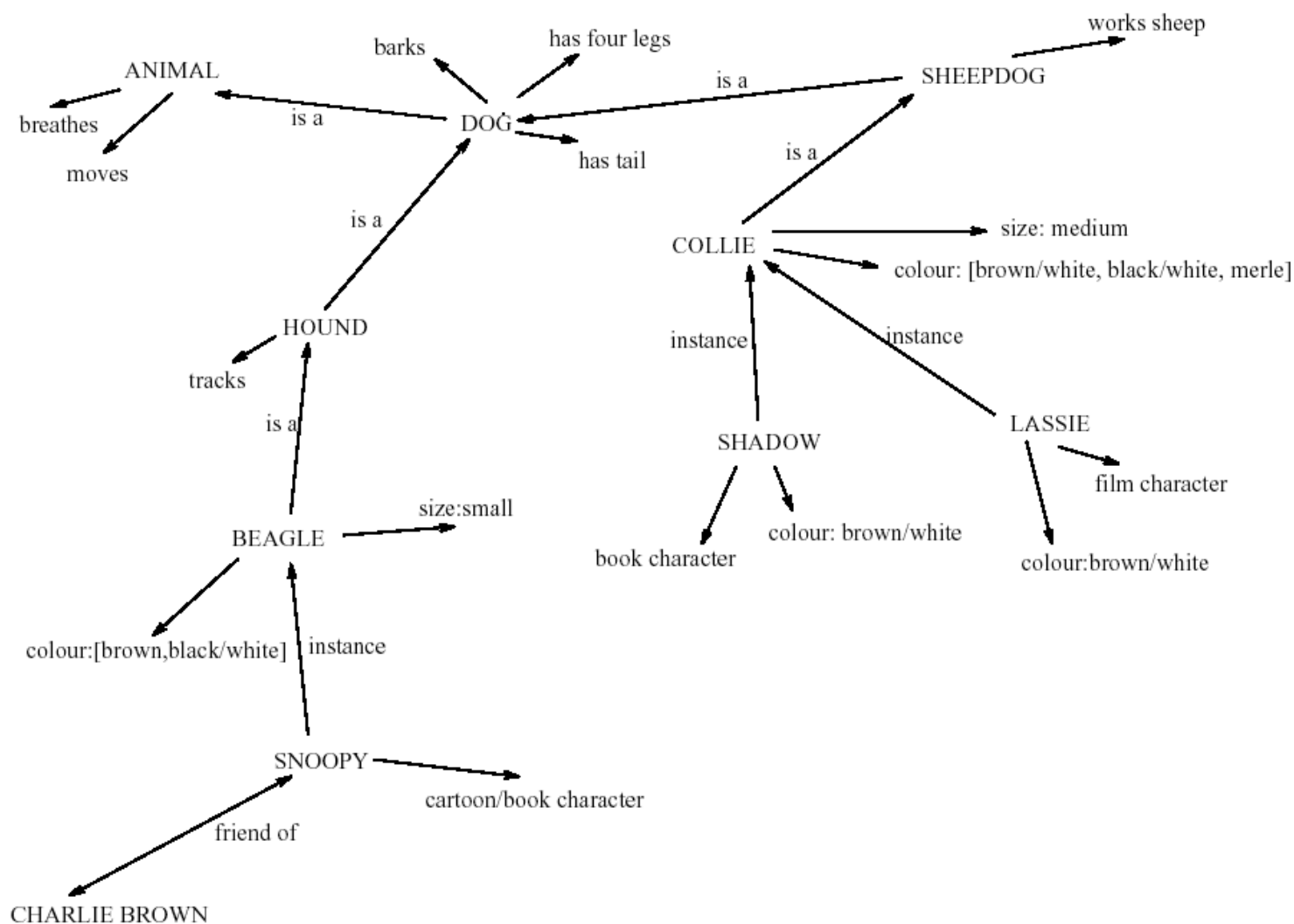
- Repository for all our knowledge
  - slow access  $\sim 1/10$  second
  - slow decay, if any
  - huge or unlimited capacity
- Two types
  - episodic – serial memory of events
  - semantic – structured memory of facts, concepts, skills

semantic LTM derived from episodic LTM

# Long-term memory (cont.)

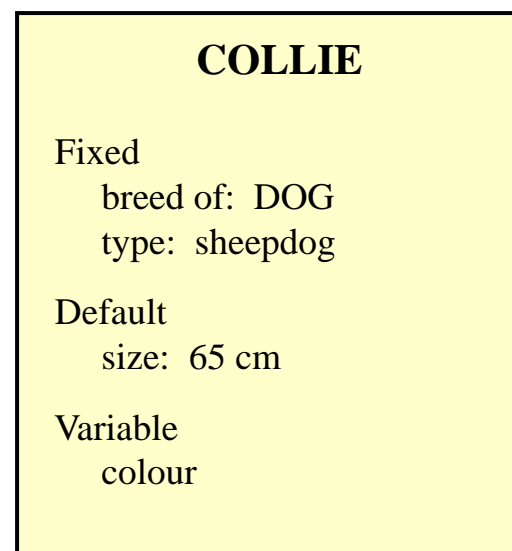
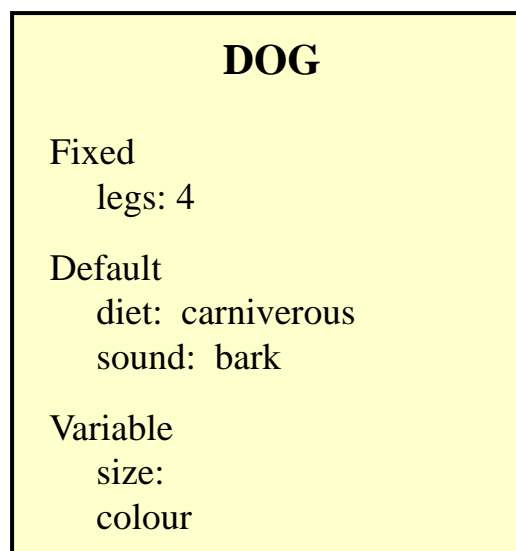
- Semantic memory structure
  - provides access to information
  - represents relationships between bits of information
  - supports inference
- Model: semantic network
  - inheritance – child nodes inherit properties of parent nodes
  - relationships between bits of information explicit
  - supports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

# LTM - semantic network



# Models of LTM - Frames

- Information organized in data structures
- Slots in structure instantiated with values for instance of data
- Type-subtype relationships



# Models of LTM - Scripts

Model of stereotypical information required to interpret situation

Script has elements that can be instantiated with values for context

## Script for a visit to the vet

Entry conditions: *dog ill*  
*vet open*  
*owner has money*

Result: *dog better*  
*owner poorer*  
*vet richer*

Props: *examination table*  
*medicine*  
*instruments*

Roles: *vet examines*  
*diagnoses*  
*treats*  
*owner brings dog in*  
*pays*  
*takes dog out*

Scenes: *arriving at reception*  
*waiting in room*  
*examination*  
*paying*

Tracks: *dog needs medicine*  
*dog needs operation*

# 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

# 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
- 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.

# 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
  - 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  
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 (cont.)

- **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

# Emotion

- 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

# Emotion (cont.)

- 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 (cont.)

- 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

# Individual differences

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

Ask yourself:

will design decision exclude section of user population?



# Psychology and the Design of Interactive System

- Some direct applications
  - e.g. blue acuity is poor  
⇒ 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 (chap 7)
  - cognitive models (chap 12)
  - experimental and analytic evaluation techniques (chap 9)