



HUMAN-COMPUTER INTERACTION

THIRD
EDITION

DIX
FINLAY
ABOWD
BEALE

chapter 1

the human



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



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

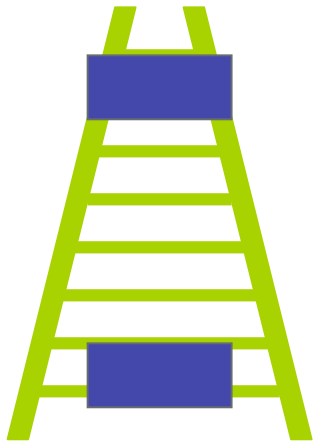


Interpreting the signal (cont)

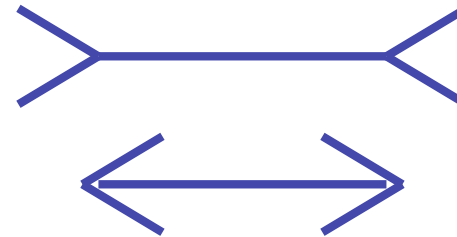
- The visual system compensates for:
 - movement
 - changes in luminance.
- Context is used to resolve ambiguity
- Optical illusions sometimes occur due to over compensation



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:

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

where: a and b are empirically determined constants

Mt is movement time

D is Distance

S is Size of target

⇒ targets as large as possible
distances as small as possible

Memory

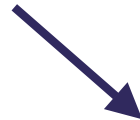
There are three types of memory function:

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 ± 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

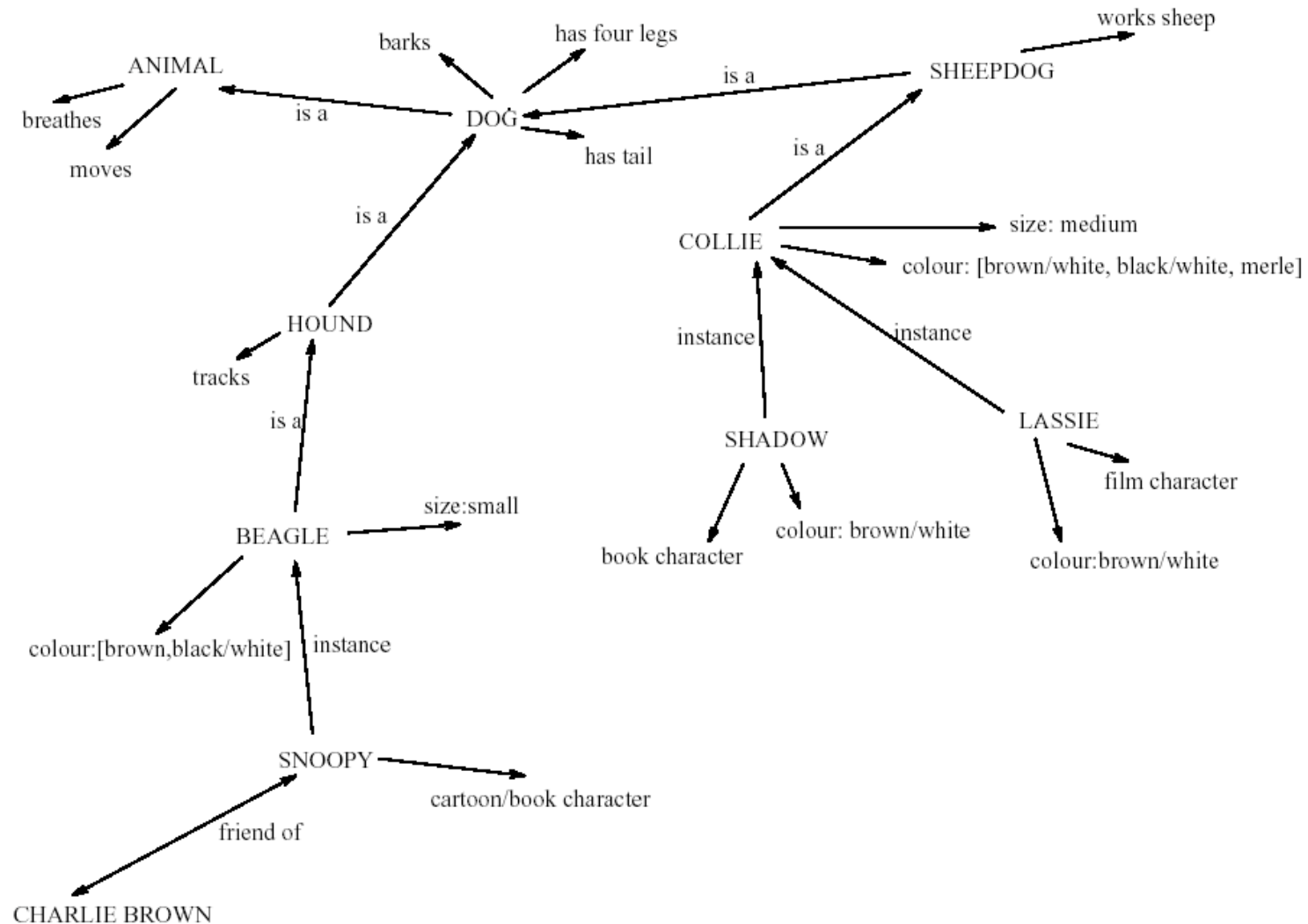
semantic LTM derived from episodic LTM



Long-term memory (cont.)

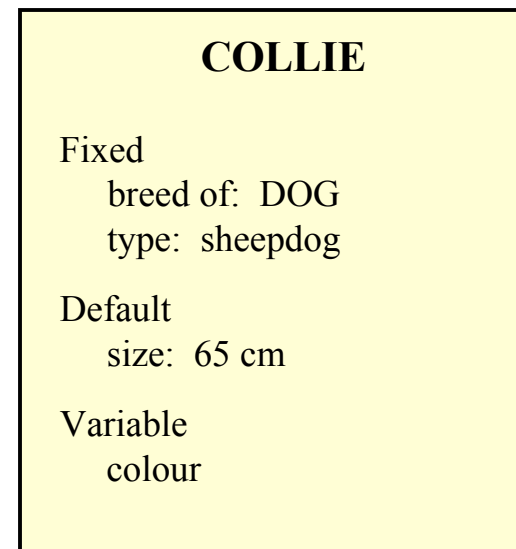
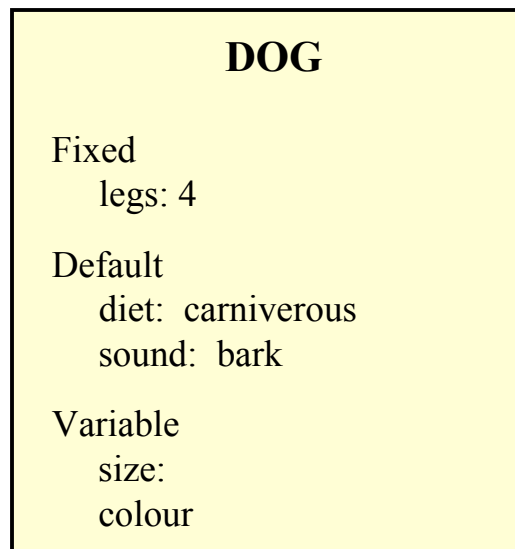
- Semantic memory structure
 - provides access to information
 - represents relationships between bits of information
 - supports inference
- Model: semantic network
 - inheritance – child nodes inherit properties of parent nodes
 - relationships between bits of information explicit
 - supports inference 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:	<i>dog ill</i> <i>vet open</i> <i>owner has money</i>	Roles:	<i>vet examines</i> <i>diagnoses</i> <i>treats</i> <i>owner brings dog in</i>
Result:	<i>dog better</i> <i>owner poorer</i> <i>vet richer</i>		<i>pays</i> <i>takes dog out</i>
Props:	<i>examination table</i> <i>medicine</i> <i>instruments</i>	Scenes:	<i>arriving at reception</i> <i>waiting in room</i> <i>examination</i> <i>paying</i>
		Tracks:	<i>dog needs medicine</i> <i>dog needs operation</i>



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.

7 E 4 K

Is this true?

.... 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
 - 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)