Vorlesung Mensch-Maschine-Interaktion

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Chapter 3
Designing Systems for Humans

- 3.1 Design for humans
- 3.2 Space and territory
- **3.3 Visual perception and reading (cont.)**
- 3.4 Hearing, Touch, Movement
- 3.5 Cognitive abilities and memory
- 3.6 Emotion
- 3.7 Natural and intuitive interaction, Affordance

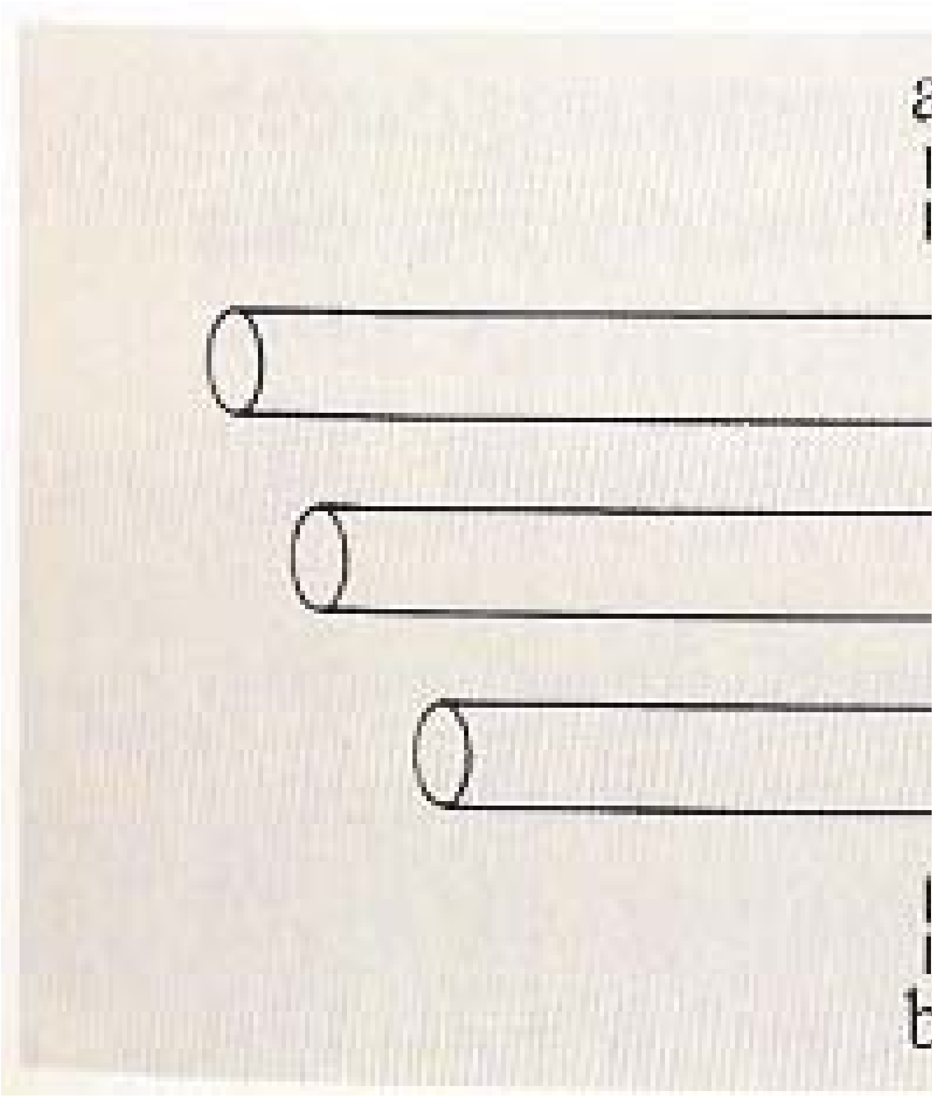
Seeing in 2D and 3D Views and Displays

- Everything on a 2D display is 2D!
  - If we see it 3 dimensional we imagine it…
  - Expectations and experience as basis
  - Displaying a projection of a 3D model

- “real” 3D needs requires a image for each eye
  - Happens naturally when looking at 3D objects in physical space
  - Can be simulated by providing a separate image for each eye using technology

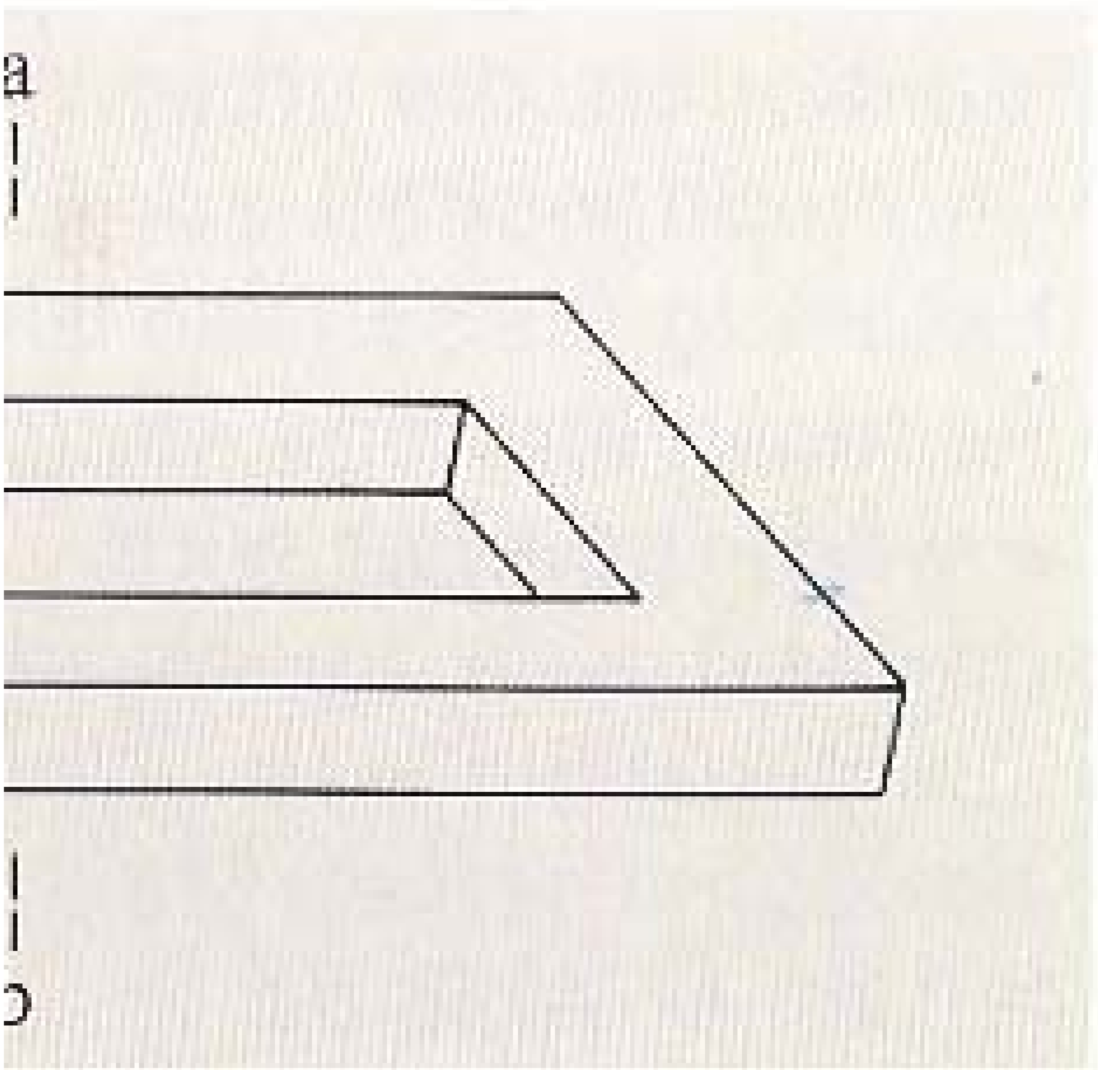
- Options to visualize 3D graphics
  - Create a 2D image that the user translates in 3D in his head
  - Provide images (that represent a 3D model from a particular view point) for both eyes
  - Create 3D structures (static or dynamic)

2D drawing: Make it conclusive…



From A. Maelicke, Vom Reiz der Sinne, VCH 1990

2D drawing: Make it conclusive…



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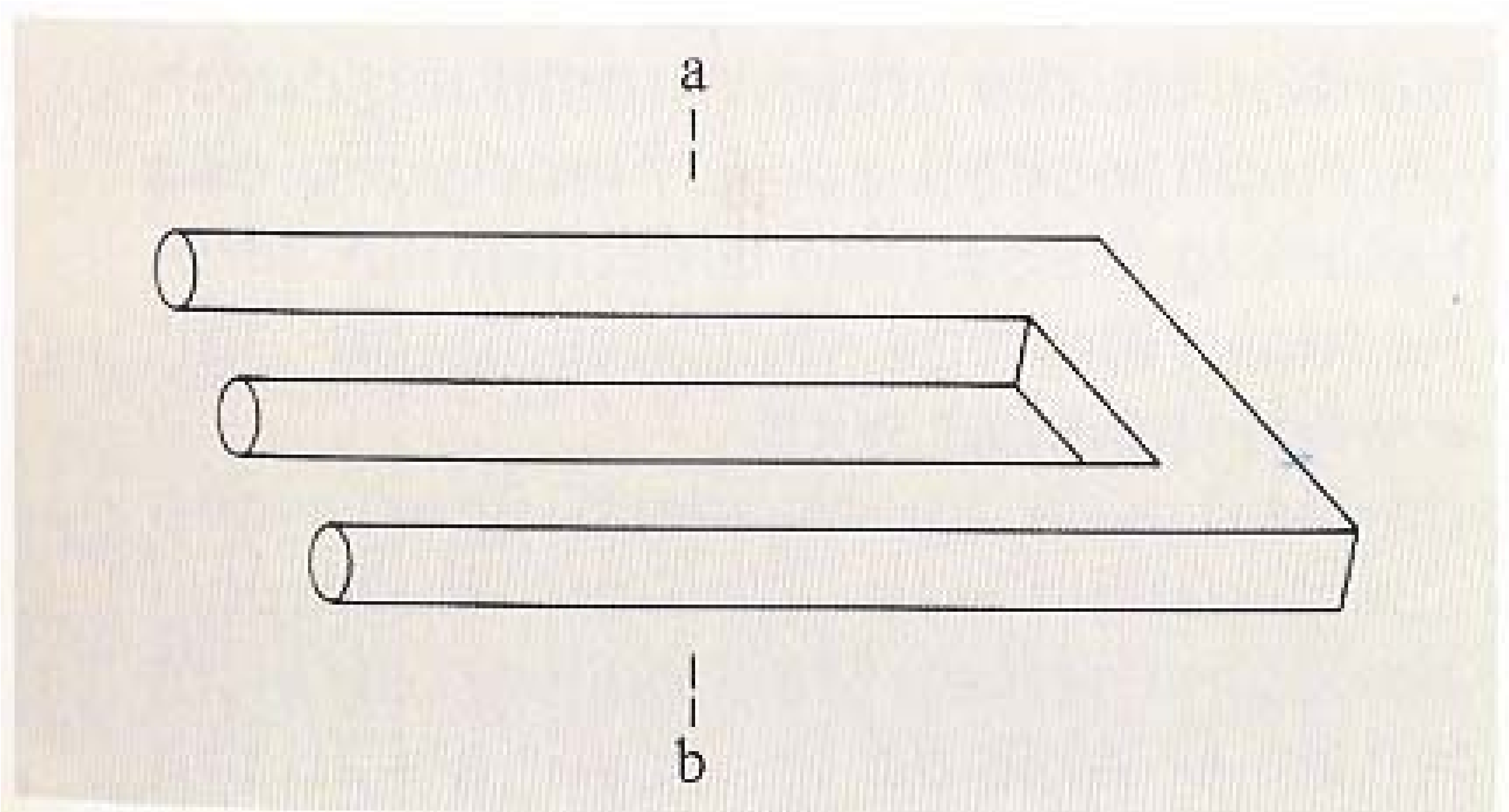
2D drawing: Make it conclusive…



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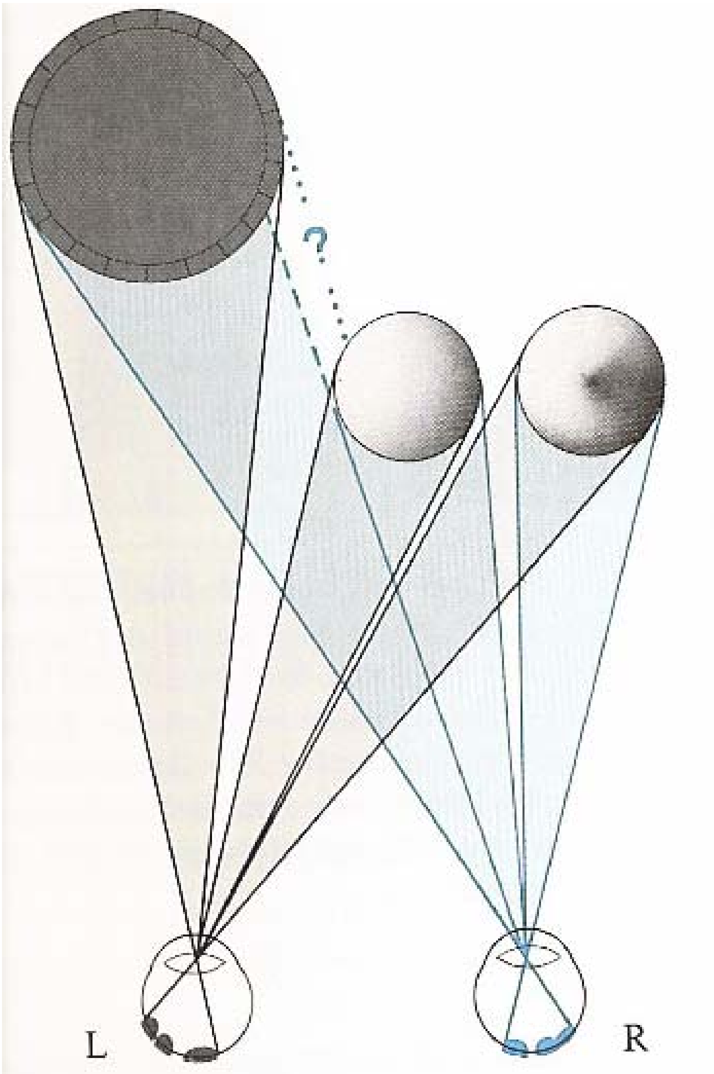
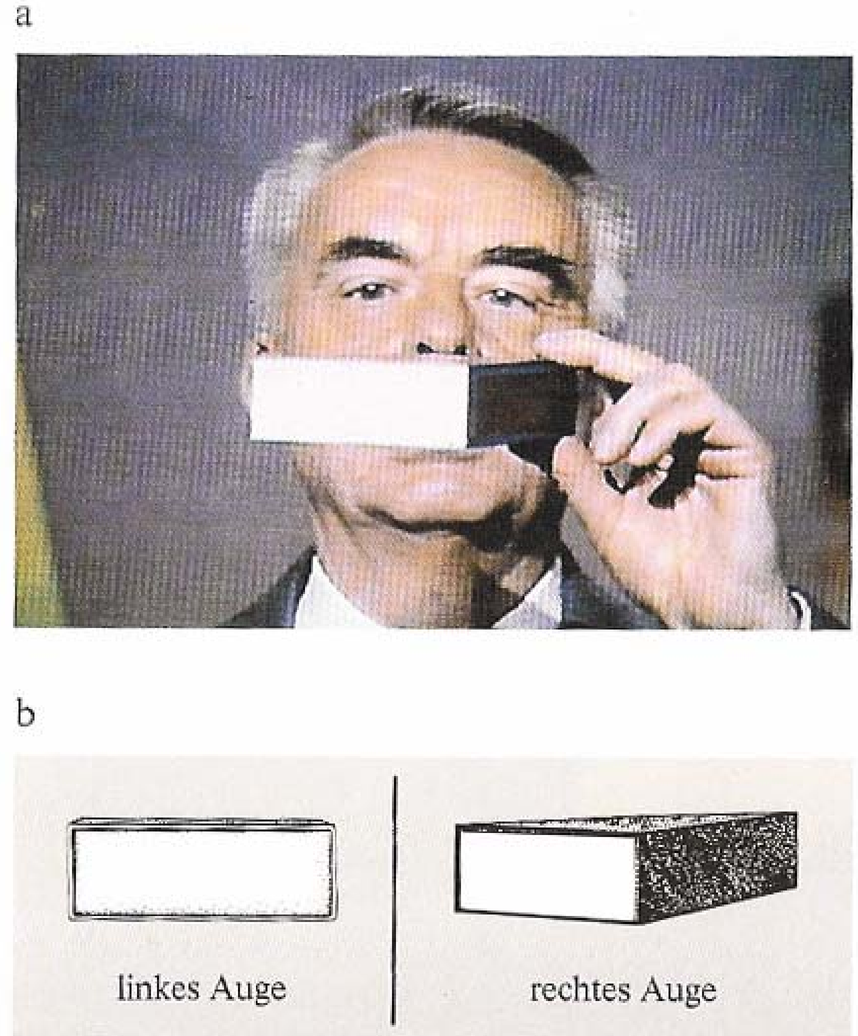
Stereo 3D Vision Basics





From A. Maelicke, Vom Reiz der Sinne, VCH 1990

Stereo 3D Vision Basics

- Image for each object is dependent on the spatial relation between object and observer
  - changing viewpoint changes the images
  - Different people at different view points see different pictures

General principles
Designing for human visual perception

- Visual design guidelines result from how humans perceive visual information
- Be aware of visual perception when designing non-standard UI components (e.g. in games and on the WWW)
  - Consider color perception
  - Consider central and peripheral vision
  - Gestalt Laws
  - Change blindness
  - Visual 3D impressions
- Be careful to make reading easy as it is an import time factor in many applications

- For more see *Advanced topics in HCI* (information visualization) and *Smart Graphics*

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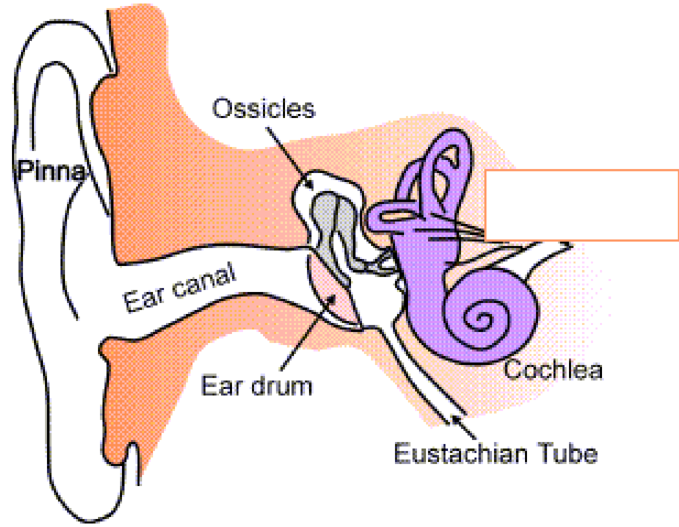
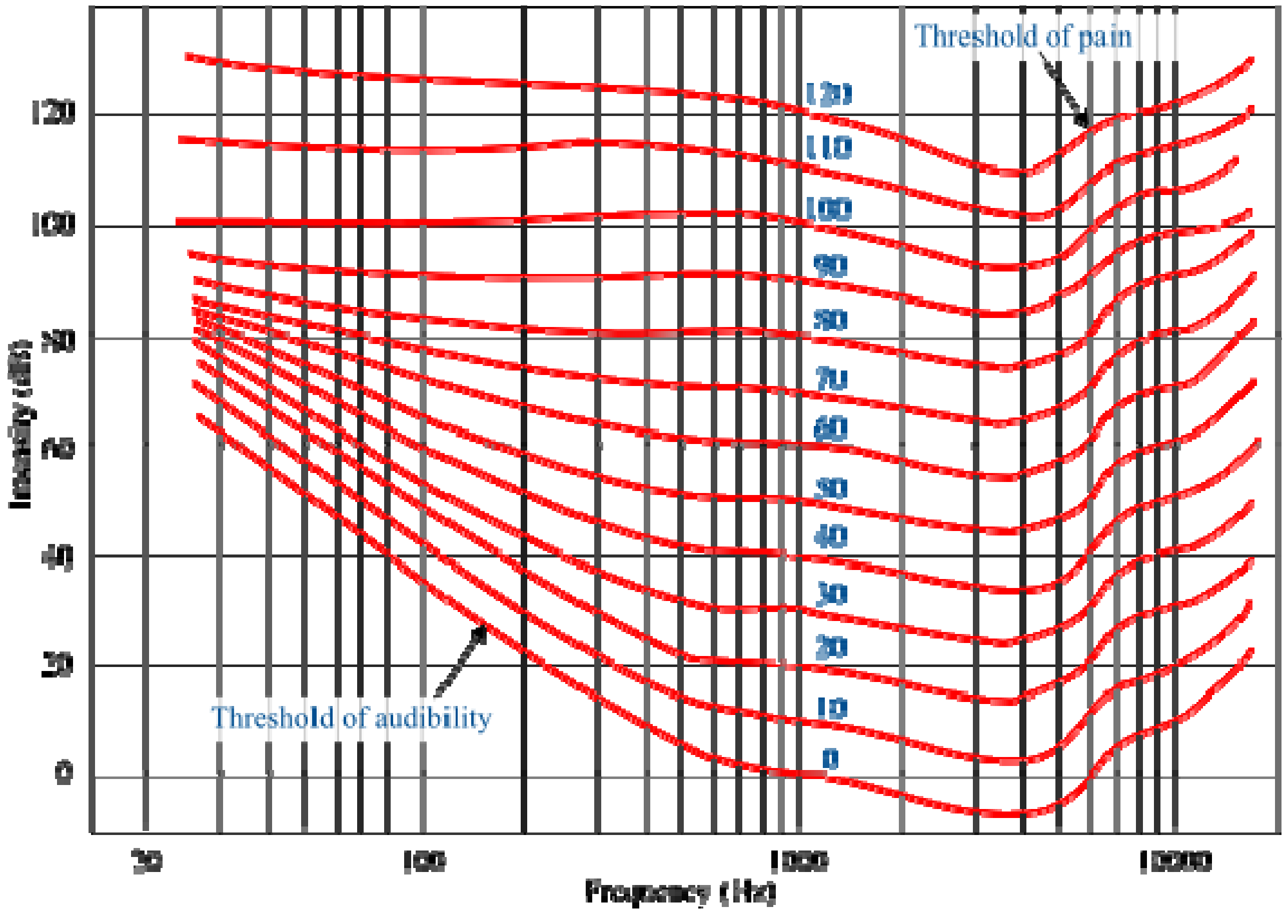
Human Ear Hearing



- 2 Ears
  - information about the environment
  - type of sound source
  - distance and direction
- Physical apparatus:
  - outer ear – protects inner and amplifies sound (3khz-12khz)
  - 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

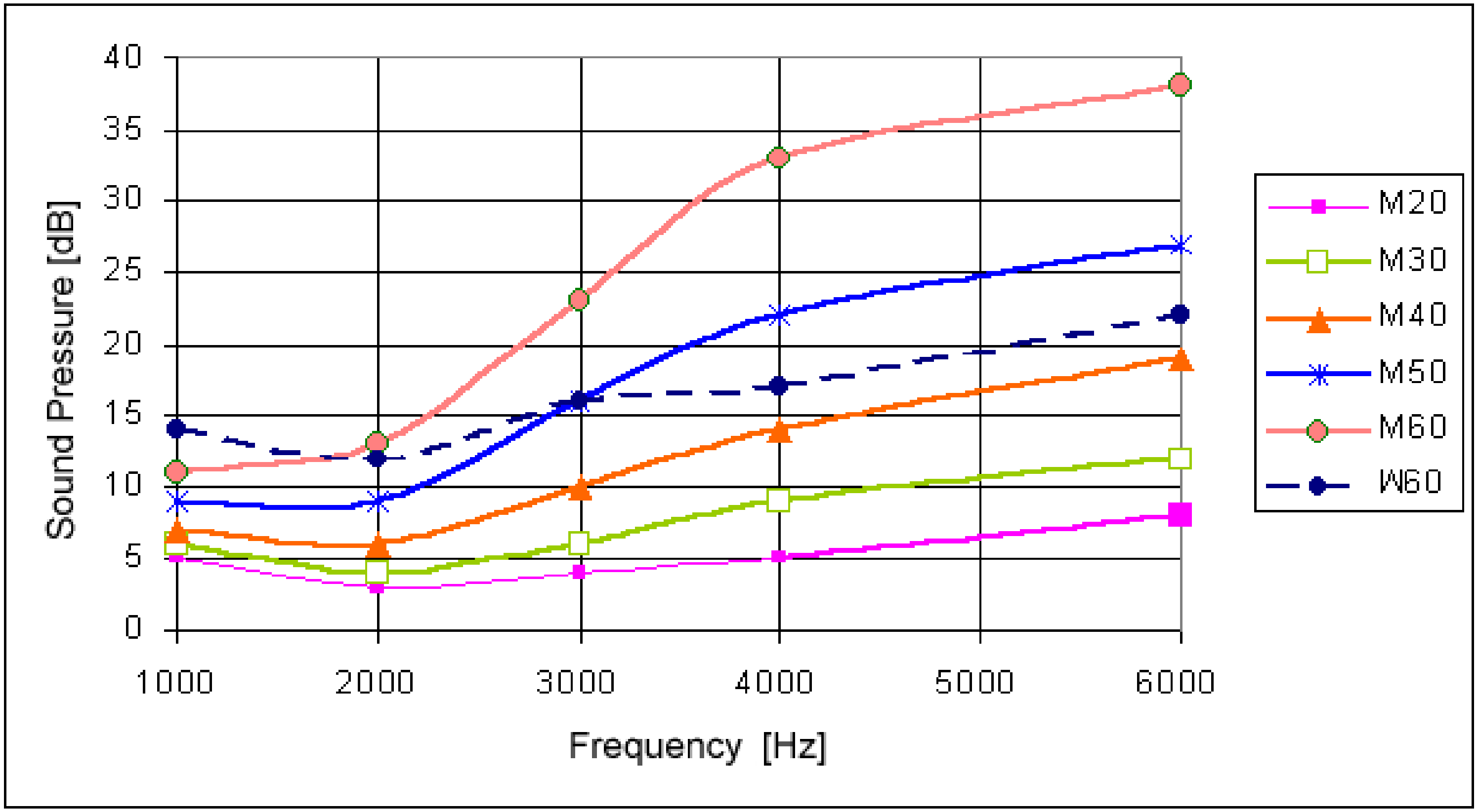
Source: Wikipedia and Dix et al.

Threshold of hearing/pain



- Fletcher-Munson equal-loudness contours
  (image from http://en.wikipedia.org/wiki/Absolute_threshold_of_hearing)

Threshold of hearing for different age groups

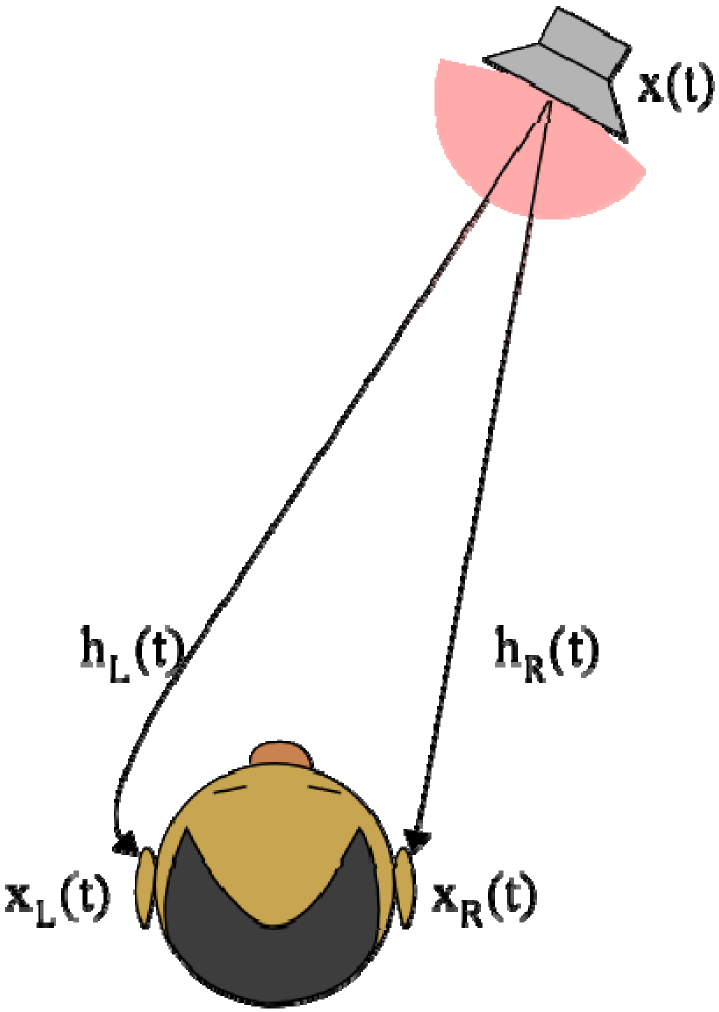


Thresholds of hearing for male (M) and female (W) subjects between the ages of 20 and 60 (for details see http://en.wikipedia.org/wiki/Absolute_threshold_of_hearing)

Hearing – Words and conversations

- Examples:
  - *You are in a noisy environment like a crowded underground train and you can still have a conversation. You can even direct your attention to another conversation and "listen in".*
  - *You are in a conversation and somewhere else someone mentions your name. You realize this even if you have not been listening actively to this conversation before.*
- The auditory system filters incoming information and allows selective hearing
  - Selectively hearing sound in environment with background noise
  - Spotting keyword, e.g. cocktail party phenomenon

Spatial hearing



- Caused by:
  - Interaural time difference (ITD)
  - Interaural intensity difference (IID)
  - Head related transfer functions (HRTF)
- Better for high than for low frequencies

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.
- Kinesthesis: the ability to feel movements of the limbs and body
- Proprioception: unconscious perception of movement and spatial orientation arising from stimuli within the body itself.
- affects comfort and performance.

(see http://www.isr.syr.edu/course/neu211/lecture_notes/lec14.html)

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.
- See Fitts' law


(experiment for visual reaction time see:
http://biology.clc.uc.edu/fankhauser/Labs/Anatomy_&_Physiology/A&P202/Nervous_System_Physiology/Visual_Reaction.htm)

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Motivation: basic calculation

- Calculate: 35 * 6
- How do you do it?

Human Memory

- “Memory is the process involved in retaining, retrieving, and using information about stimuli, images, events, ideas, and skills after the original is not longer present.” (Goldstein, p. 136)

Memory Model

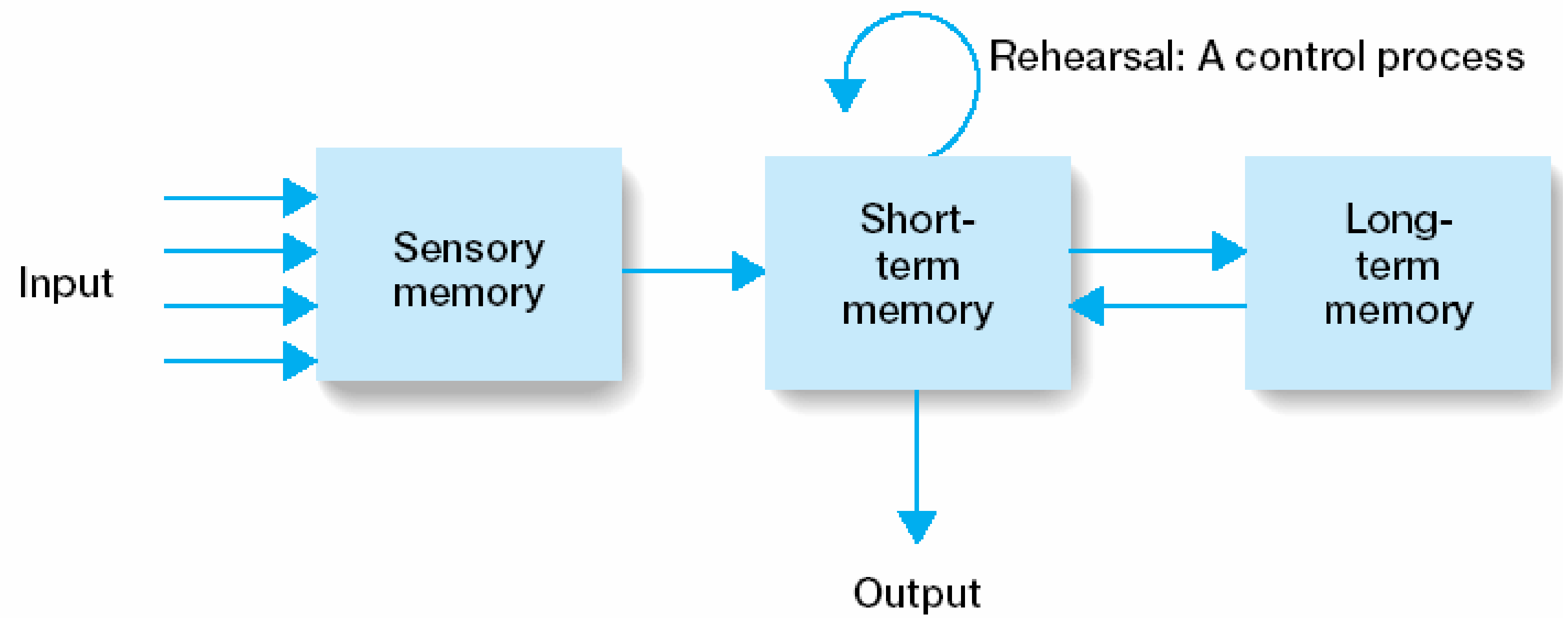
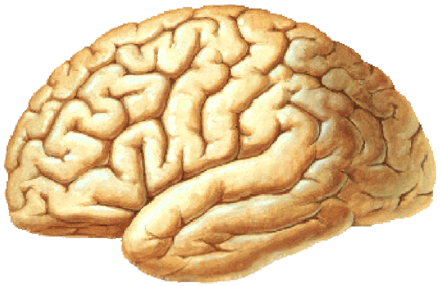


Figure 5.3 Flow diagram for Atkinson and Shiffrin's (1968) model of memory. This model, which is described in the text, is called the *modal model* because of the huge influence it has had on memory research.

- (from: Goldstein, p. 139)

Memory



- Involves encoding and recalling knowledge and acting appropriately
- We don’t remember everything - involves filtering and processing
- Context is important in affecting our memory
- We recognize things much better than being able to recall things
  - The rise of the GUI over command-based interfaces
- Better at remembering images than words
  - The use of icons rather than names

Motivation: memorizing

- Memorize

  2 7 5 9 2 8 1 2 9 1 6 3

  49 179 23 89 481

  49 1 pizza now

  heh ousew asg reena ndb igt

The problem with the classic ‘7±2’

- George Miller’s theory of how much information people can remember
- http://www.well.com/user/smalin/miller.html
  (The Psychological Review, 1956, vol. 63, pp. 81-97)
- People’s immediate memory capacity is very limited
- In general you can remember 5-9 chunks – and chunks can be letters, numbers, words, sentences, images, …

Wrong application of the theory

- Many designers have been led to believe that this is a useful finding for interaction design
  - Present only 7 options on a menu
  - Display only 7 icons on a tool bar
  - Have no more than 7 bullets in a list
  - Place only 7 items on a pull down menu
  - Place only 7 tabs on the top of a website page
- **But this is wrong!**
  Why?
  - Inappropriate application of the theory
  - People can scan lists of bullets, tabs, menu items till they see the one they want
  - They don’t have to recall them from memory having only briefly heard or seen them

Motivation: Wason's cards

7 E 4 K

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?

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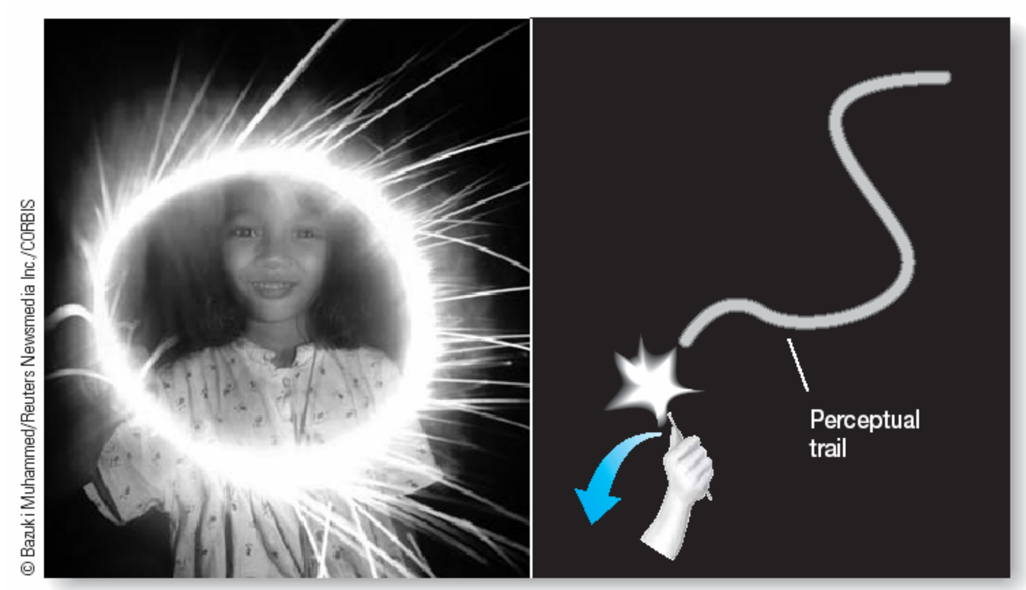
Sensory Memory

- "Sensory Memory is the retention, for brief periods of time, of the effects of sensory stimulation." (Goldstein, p. 140)
- E.g. Persistence of vision

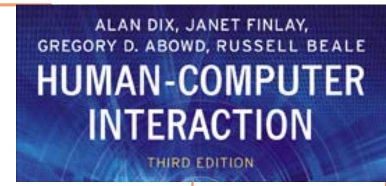


(Image from Goldstein, p. 142)

Sensory Memory functions

1. collecting information for processing
2. holding information briefly while initial processing is going on
3. filling in the blanks when stimulation is intermittent

(from: Goldstein, p. 145)



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
  - watching a film
- Continuously overwritten

Short-term memory (STM)

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

Coding of information

- Visual – image of a person
- Phonological – sound of a voice
- Semantic – meaning of what a person is saying

- Coding in Short Term Memory
  - Sound is most efficient

- When users have to remember something in the application → make it possible to code it phonological

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
  - 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

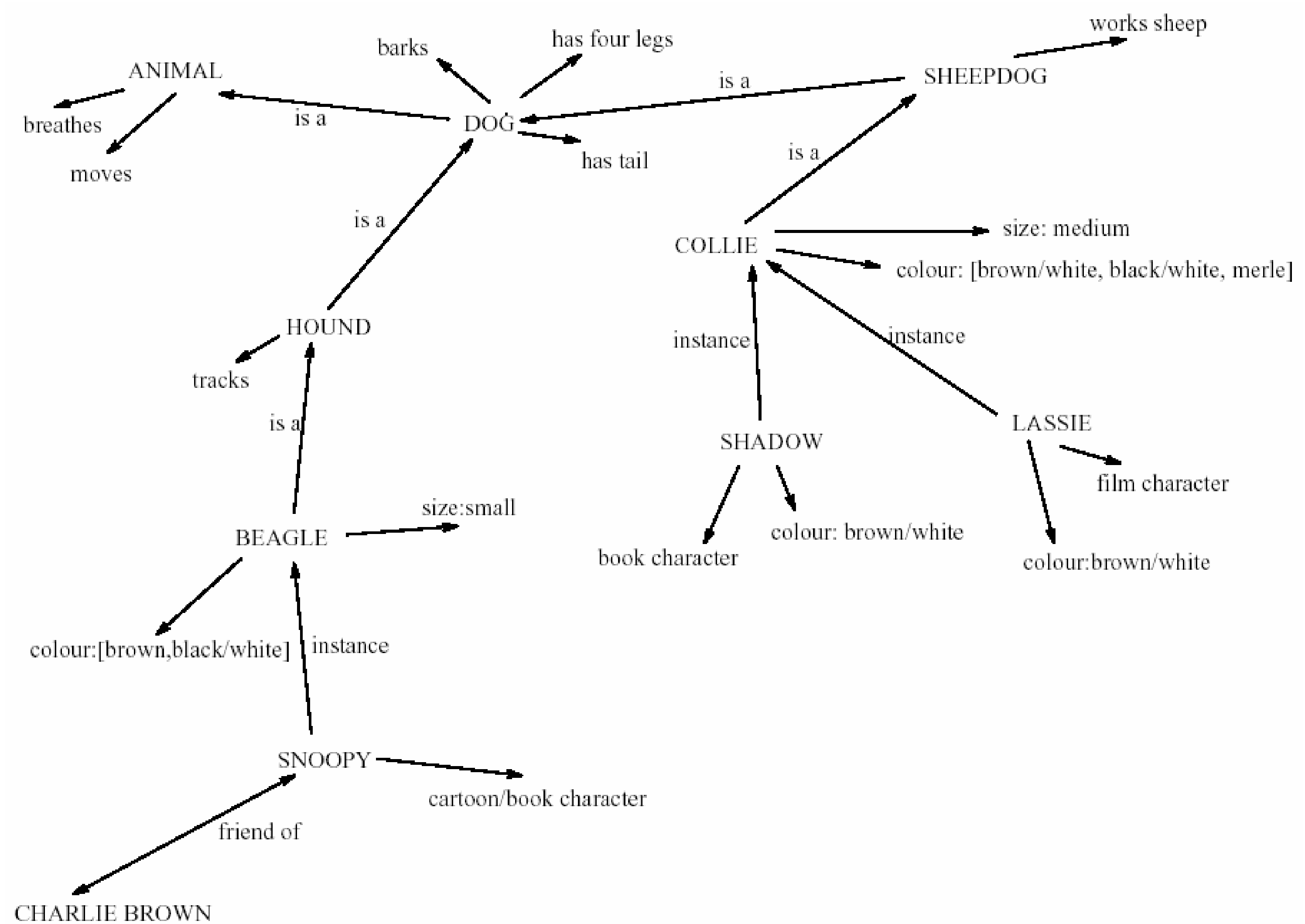
Motivation: Decisions and long term memory

- *Do dogs bark? Yes/No*

- *Do dogs breathe? Yes/No*

- The second question takes longer to answer → this indicates semantic coding!

LTM - semantic network



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

- 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

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Emotions
Attractive Things Work Better

- Experiment
  - Six ATM identical in function and operation
  - Some aesthetically more attractive than others
  - Result: the nicer one's are easier to use…

- Aesthetics can change the emotional state
- Emotions all us to quickly assess situations
  - Positive emotion make us more creative

- Attractive things make feel people good
  → they are more creative
  → things are easier to use…

- See D. Norman, Emotional Design (Chapter 1)

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

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Affordance Theory

- **Affordance is the perceived possibility for action**

- Objective properties that imply action possibilities - how we can use things – independent of the individual. (Gibson)
- Perceived Affordance includes expierence of an individual (Norman)

- Example: vandalism at a bus stop
  - Concrete → graffiti
  - Glass → smash
  - Wood → carvings

Gibson, J.J. (1979). *The Ecological Approach to Visual Perception*, Houghton Mifflin, Boston. (Currently published by Lawrence Eribaum, Hillsdale, NJ.)

Norman, D. A. (1988). The Psychology of Everyday Things. New York: Basic Books. (The paperback version is Norman, 1990.)

Natural and Intuitive User Interfaces?

- Very little is intuitive and natural with regard to computer user interfaces!
- To make it feel intuitive and natural
  - Base UIs on previous knowledge of the user
  - Use clear affordances and constraints

Donald A. Norman, Affordance, conventions, and design, *Interactions*. Volume 6, Number 3 (1999), Pages 38-41 http://www.cit.gu.edu.au/~mf/2506CIT/norm99.pdf

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