3 Capabilities of Humans and Machines

3.1 Designing Systems for Humans

3.2 Space and Territory

3.3 Visual Perception and User Interfaces

3.4 Hearing, Touch, Movement in User Interfaces

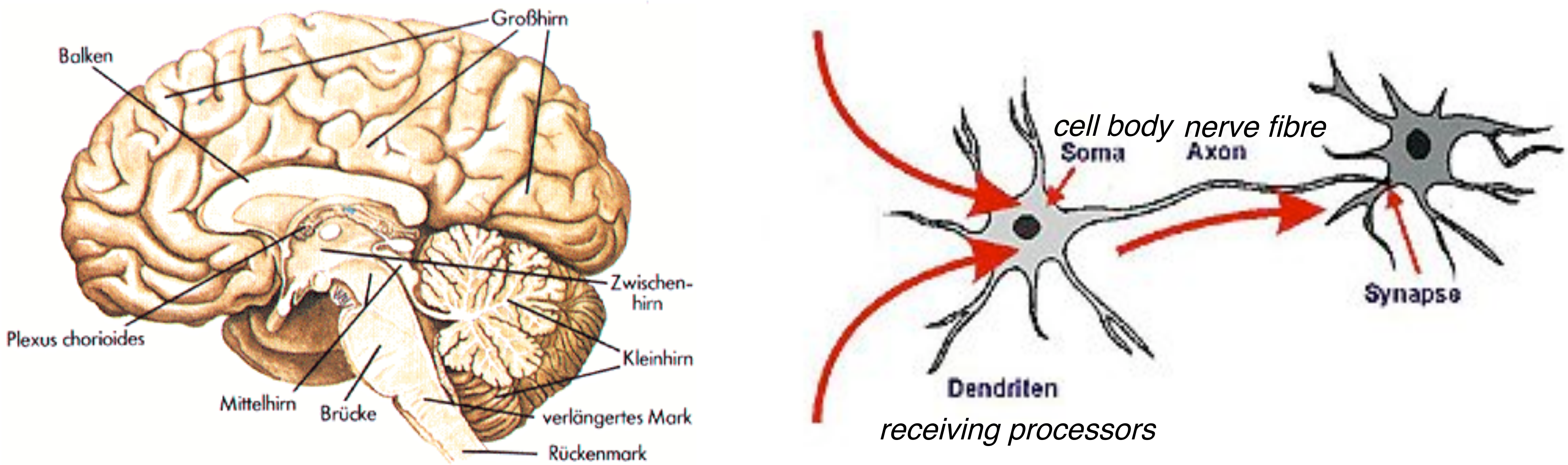
3.5 Cognitive Abilities and Memory

3.6 Hardware Technologies for Interaction

3.7 Natural and Intuitive Interaction, Affordances

Corresponding extension topic:
E3 Advanced Interface Technologies

Physiology of Memory



- Memory can be explained as structural change on synaptic level
  - Synaptic connections are enforced/multiplied and reduced
- Since the 60s multi-level models of human memory are used

Model of 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)

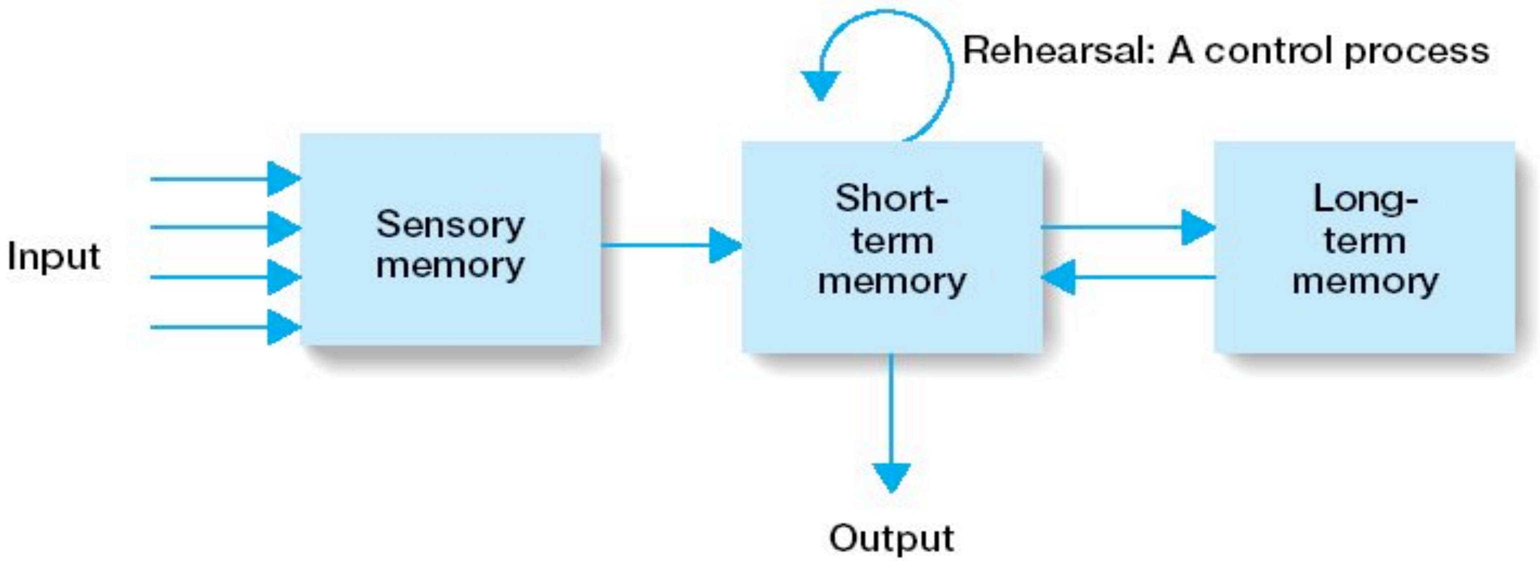
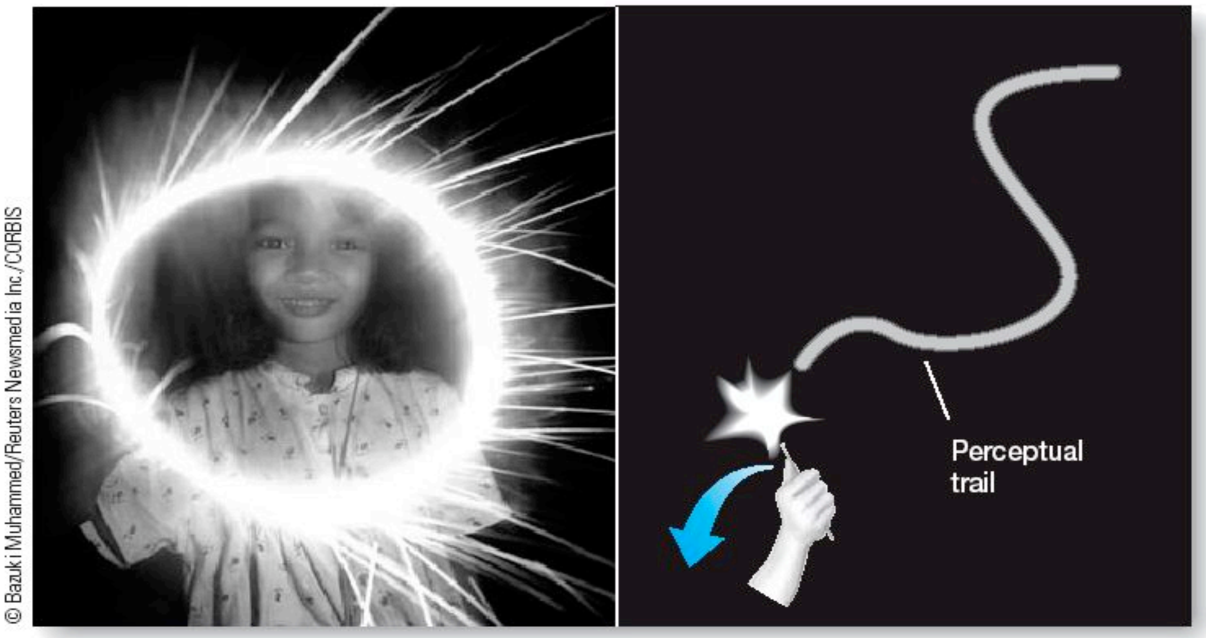


Figure 5.3 Flow diagram for Atkinson and Shiffrin's (1968) model of memory. This model, which is described in the text, is called the *modal model* because of the huge influence it has had on memory research.

(from: Goldstein, p. 139)

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

- Sensory memory functions:
  - collecting information for processing
  - selective, controlled by other (conscious and unconscious) processes
  - holding information briefly while initial processing is going on
  - filling in the blanks when stimulation is intermittent

    (from: Goldstein, p. 145)
- 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 Example: Memorizing

- Memorize:

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

49 174 99 26 69

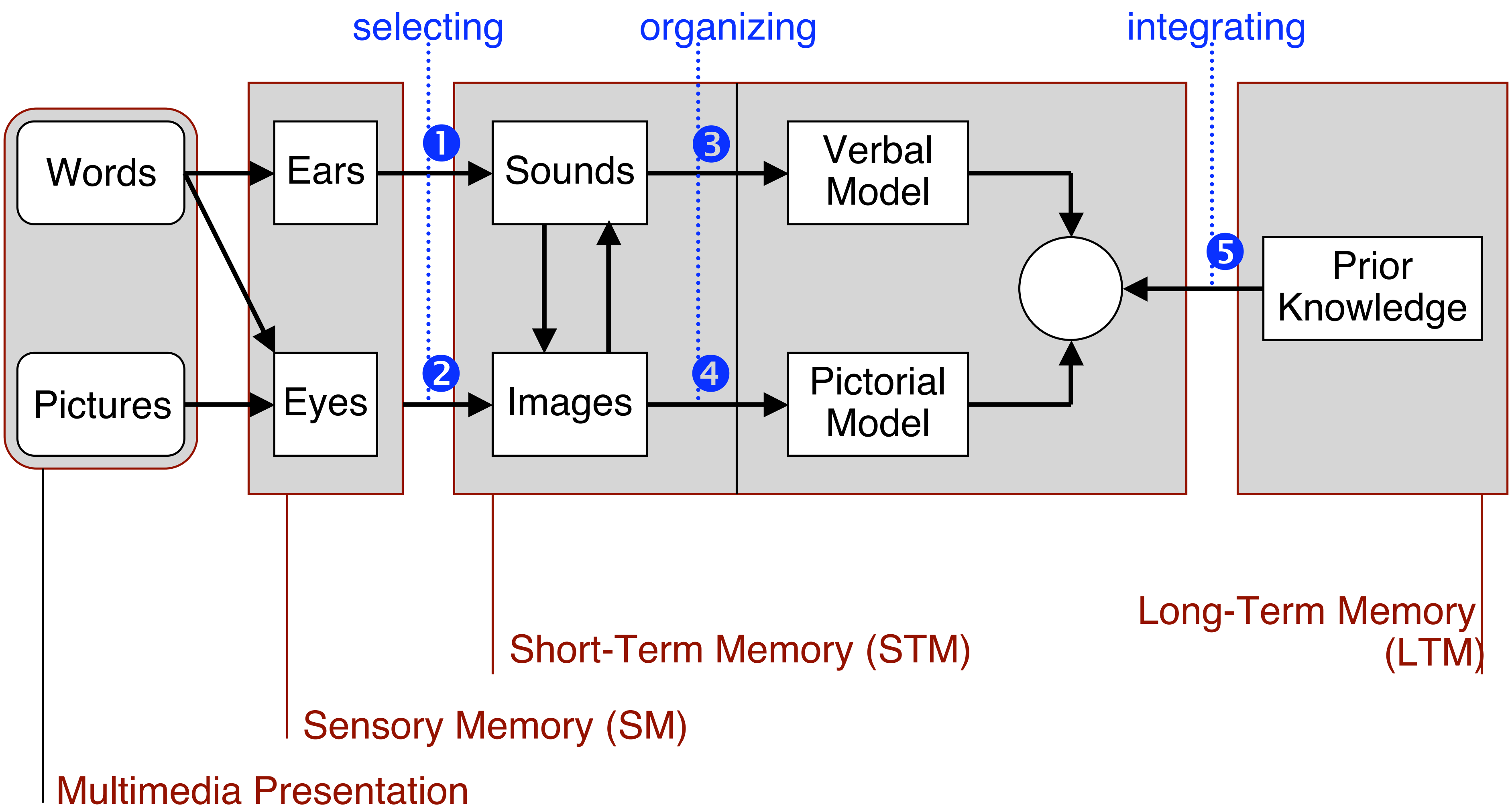
49 1 pizza now

heh ousew asg reena ndb igt

Short-Term Memory (STM)

- Scratch-pad for temporary recall
  - rapid access ~ 70ms
  - rapid decay ~ 200ms
  - limited capacity: 7± 2 “chunks”
- Transition from SM to STM
  - by focusing attention
  - kept in STM by rehearsal
- 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 one can remember 5-9 chunks
  - Chunks can be letters, numbers, words, sentences, images, …
- Modern theory speaks of *Working Memory* instead of STM
  - stresses manipulation of contents

Cognitive Model of Multimedia Learning



Richard Meyer 2001

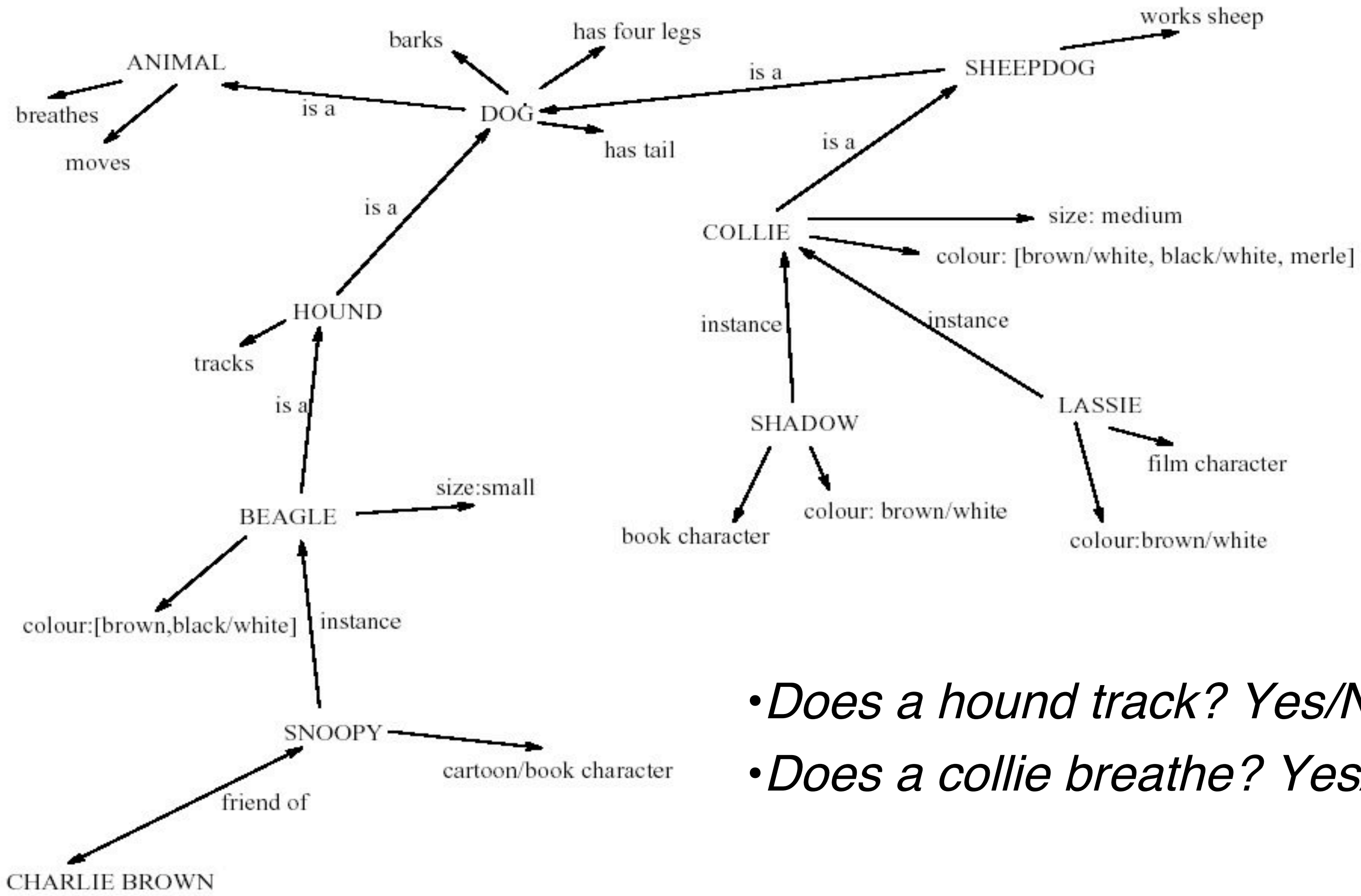
Careful Application of the Miller Theory

- Does the 7± 2 rule give guidance in interaction design?
  - Present at most 7 options on a menu
  - Display at most 7 icons on a tool bar
  - Have no more than 7 bullets in a list
  - Place at most 7 items on a pull down menu
  - Place at most 7 tabs on the top of a website page
- **But this is wrong!**
  Why?
  - People can scan lists of bullets, tabs, menu items, they don't have to recall them from memory
  - People have a tendency to *externalize* memory
    - » Memory in the environment
    - » See chapter on space

Long-term memory (LTM)

- Repository for all our knowledge
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge or unlimited capacity
- Two types of LTM
  - episodic – serial memory of events
  - semantic – structured memory of facts,concepts, skills
- Semantic memory structure
  - provides access to information
  - represents relationships between bits of information
  - supports inference
  - Model: semantic network

LTM - semantic network



- *Does a hound track? Yes/No*
- *Does a collie breathe? Yes/No*

- The second question takes longer to answer!

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 and Retrieval

Forgetting:

- decay
  - » information is lost (made less accessible?) gradually but very slowly
- interference
  - » new information replaces old: retroactive interference
  - » old may interfere with new: proactive inhibition

all memory is selective, affected by emotion, may "choose" to forget

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: Modes of 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, dependent on assumptions
- 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 be disproven
- Abduction:
  - 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

Example for Inductive Reasoning: 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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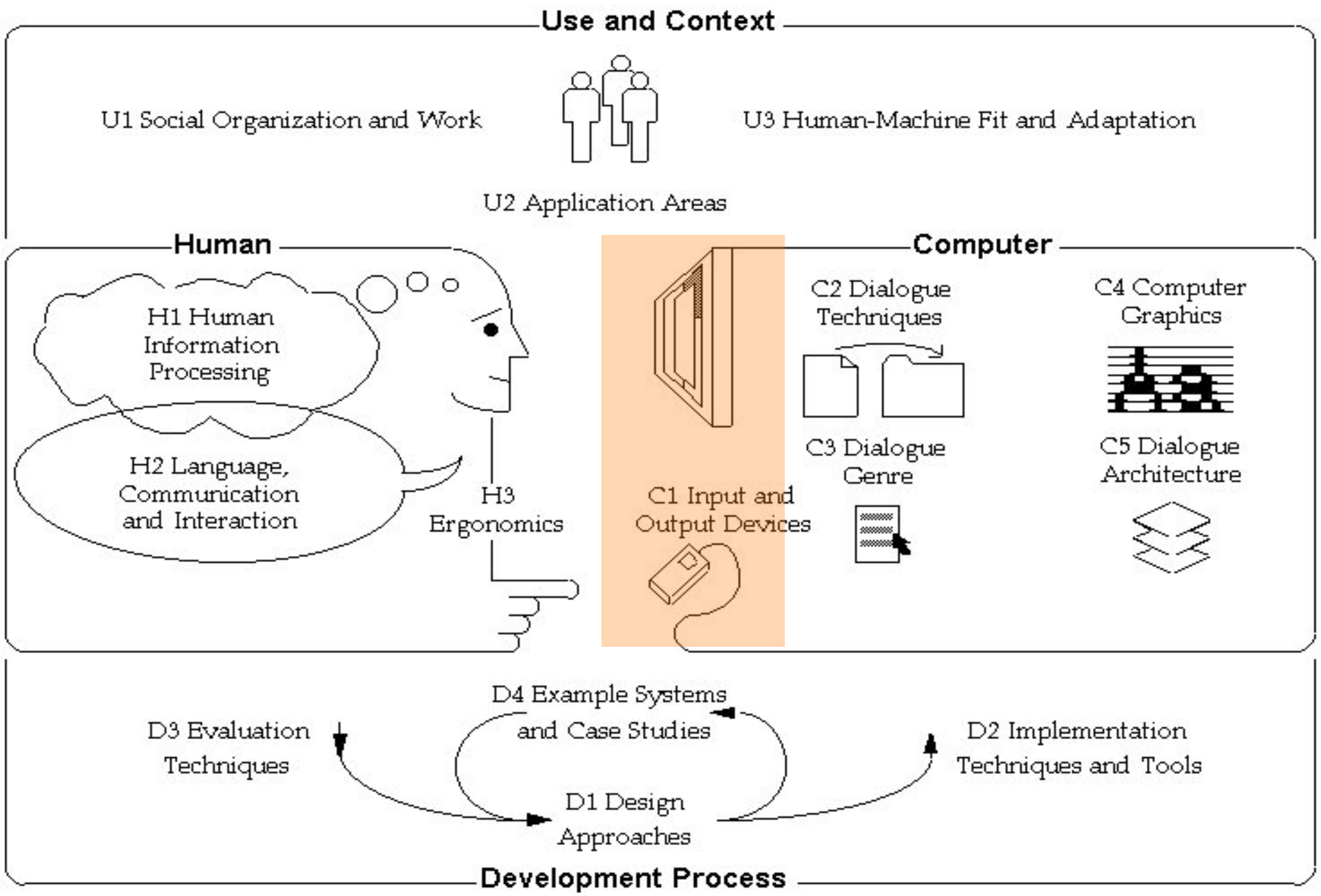
3 Capabilities of Humans and Machines

Corresponding extension topic:

E3 Advanced Interface Technologies



What are the prerequisites on the computer side?

See lecture “Medientechnik”!

Basic Input Operations

- Text Input
  - Continuous
    - » Keyboard and alike
    - » Handwriting
    - » Spoken
  - Block
    - » Scan/digital camera and OCR
- Pointing & Selection
  - Degree of Freedom
    - » 1, 2, 3, 6, <more> DOF
  - Isotonic vs. Isometric
  - Translation function
  - Precision
  - Technology
  - Feedback
- Direct Mapped Controls
  - Hard wired buttons/controls
    - » On/off switch
    - » Volume slider
  - Physical controls that can be mapped
    - » Softkeys on mobile devices
    - » Function keys on keyboards
    - » Industrial applications
- Media capture
  - Media type
    - » Audio
    - » Images
    - » Video
  - Quality/Resolution
  - Technology

Basic Output Operations

- Visual Output
  - Show static
    - » Text
    - » Images
    - » Graphics
  - Animation
    - » Text
    - » Graphics
    - » Video
- Audio
  - Earcons / auditory icons
  - Synthetic sounds
  - Spoken text (natural / synthetic)
  - Music
- Tactile
  - Shapes
  - Forces
- Further senses
  - Smell
  - Temperature
  - …
- Technologies
  - Visual
    - » Paper
    - » Objects
    - » Displays
  - Audio
    - » Speakers/Headphones
    - » 1D/2D/3D
  - Tactile
    - » Objects
    - » Active force feedback

Design Space and Technologies

Why do we need to know about input/output technologies?

- For standard applications
  - Optimal adaptation to human workflow
  - Support for user variety
- For specific custom made applications
  - Understanding available options
  - Creating a different experience (e.g. for exhibition, trade fare, museum, …)

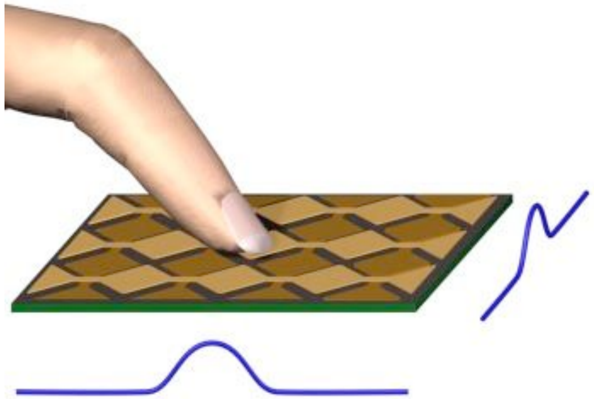
Analysis of the Computer’s “Senses”

- Chris Crawford 2002 p. 50 ff

Computer‘s steps	**1980 Technology**	**2000 Technology**	**Improvement Factor**
Speaking	24 x 80 B&W Characters Sound = beep	800 x 600 24-Bit colors Graphics 44 kHz Stereo	1000 x
Thinking	1 MHz 8-bit 16 K RAM	300 MHz 32-bit 64 MB RAM	4 000 000 x
Listening	Keyboard	Keyboard + Mouse	2 x

The “speaking” abilities of computers (visual and auditive) are well developed – they go beyond the human “hearing” abilities.
The “hearing” abilities of computers are dramatically underdeveloped.
This asymmetry makes communication very difficult.

Examples of Desktop-Oriented Pointing Devices (most with additional functionality)



Classification of Pointing devices

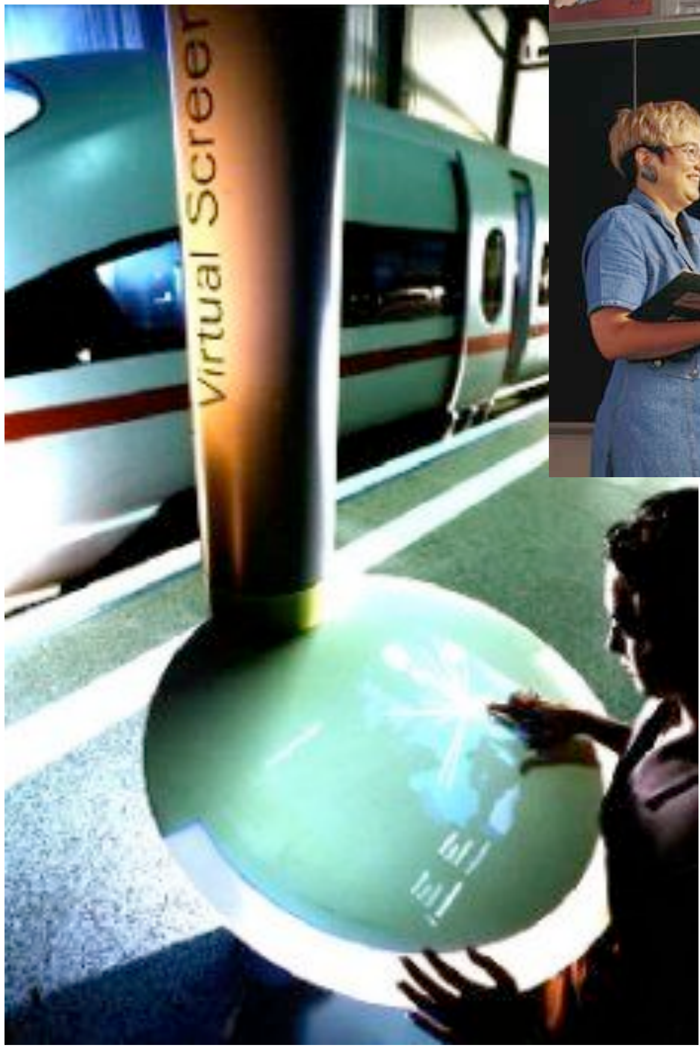
- Dimensions
  - 1D / 2D / 3D

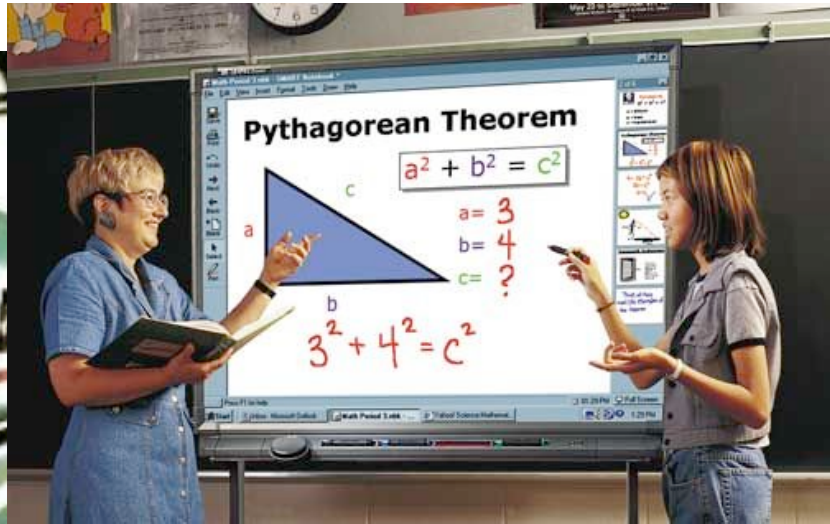
- Direct vs. indirect
  → integration with the visual representation
  - Touch screen is direct
  - Mouse is indirect

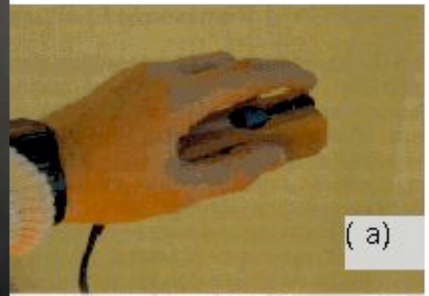
- Discreet vs. continuous
  → resolution of the sensing
  - Touch screen is discreet
  - Mouse is continuous

- Absolute vs. Relative
  →movement/position used as input
  - Touch screen is absolute
  - Mouse is relative

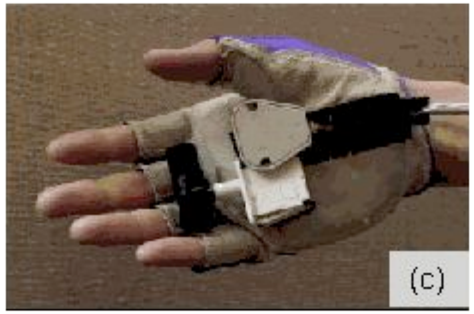
Examples of Off-Desktop Pointing Devices





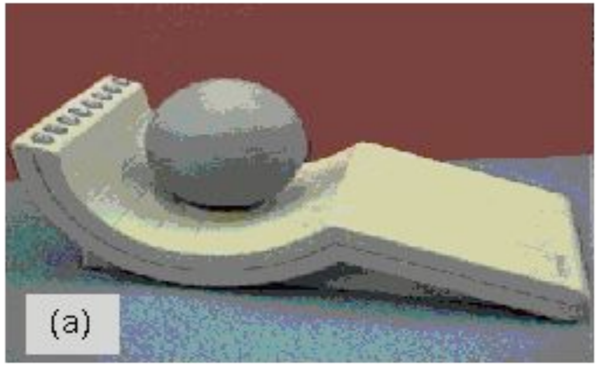

(a)

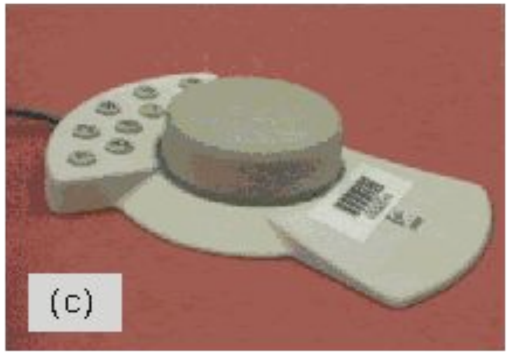

(b)


(c)

Stationary Pointing Devices

- Devices mounted on stationary surface.
- Have a self-centering mechanism
- *isometric* devices:
  – do not move by a significantly perceptible magnitude
- *elastic devices*:
  – movable, spring-loaded.
- *rate control* mode
  – input variable, either force or displacement, is mapped onto velocity of the cursor.
  – cursor position is the integration of input variable over time.
- Pros/cons of isometric devices with rate control:
  – Reduced fatigue
  – Better precision and smoother movement
  – Needs to be learned
  – Lack of control feel





Taxonomy for Input Devices (Buxton)

- continuous *vs* discrete?
- agent of control (hand, foot, voice, eyes ...)?

- what is being sensed (position, motion or pressure), and
- the number of dimensions being sensed (1, 2 or 3)

- devices that are operated using similar motor skills
- devices that are operated by touch vs. those that require a mechanical intermediary between the hand and the sensing mechanism

"…basically, an input device is a transducer from the physical properties of the world into the logical parameters of an application." (Bill Buxton)

Taxonomy for Input Devices (Buxton)

Property Sensed		Number of Dimensions: 1		2				3	
Position		Rotary Pot	Sliding Pot	Tablet & Puck	Tablet & Stylus	Light Pen	Isotonic Joystick	3D Joystick	M
Position					Touch Tablet	Touch Screen			T
Motion		Continuous Rotary Pot	Treadmill	Mouse			Sprung Joystick Trackball	3D Trackball	M
Motion			Ferinstat				X/Y Pad		T
Pressure		Torque Sensor					Isometric Joystick		T
		rotary	linear	puck	stylus finger hoiz.	stylus finger vertical	small fixed location	small fixed with twist	

http://www.billbuxton.com/lexical.html

Buxton, W. (1983). Lexical and Pragmatic Considerations of Input Structures. *Computer Graphics,* 17 (1), 31-37.

Physical Properties used by Input devices (Card et al)

	Linear	Rotary
Position		
Absolute	P (Position)	R (Rotation)
Relative	dP	dR
Force		
Absolute	F (Force)	T (Torque)
Relative	dF	dT

Card, S. K., Mackinlay, J. D. and Robertson, G. G. (1991).
A Morphological Analysis of the Design Space of Input Devices.
ACM Transactions on Information Systems 9(2 April): 99-122

Input Device Taxonomy (Card et al)

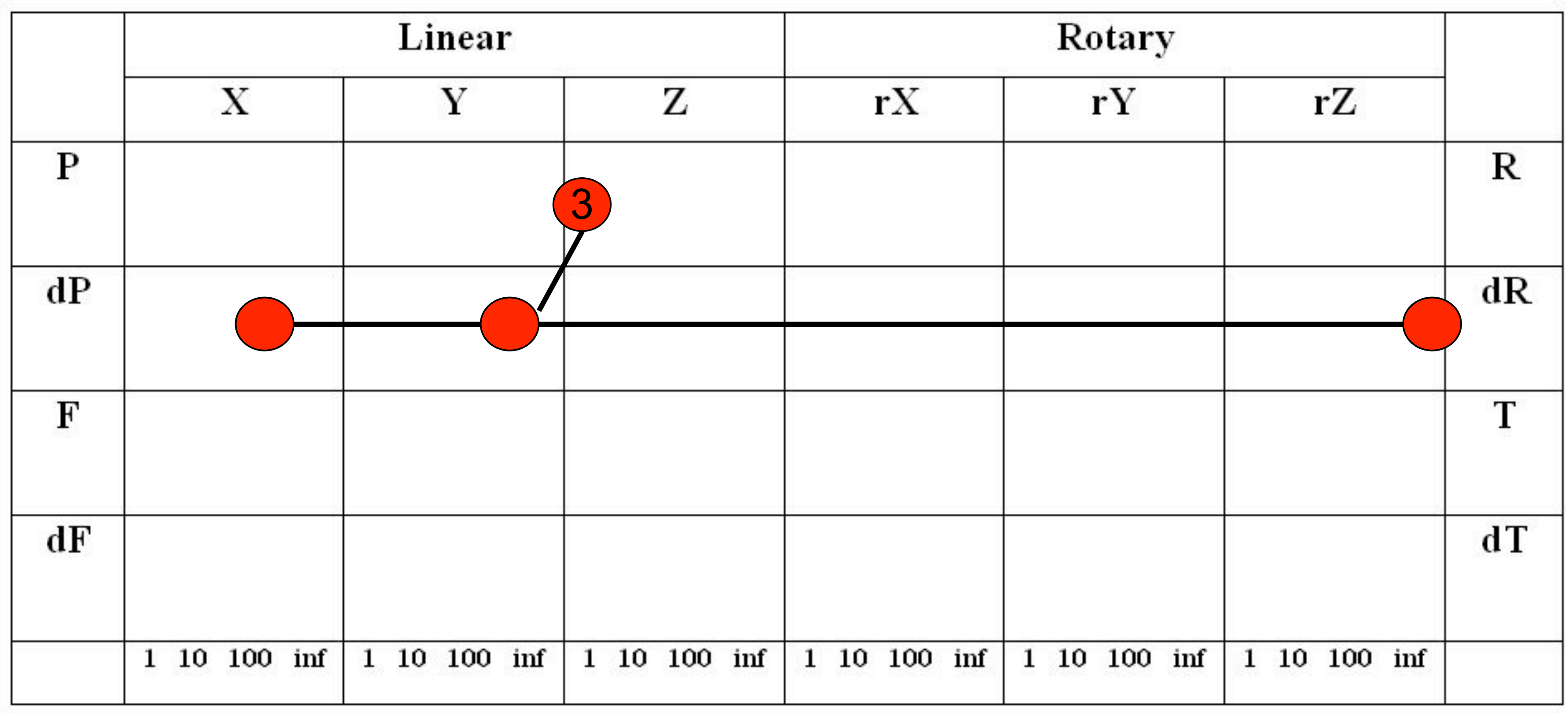
	Linear			Rotary			
	X	Y	Z	rX	rY	rZ	
P							R
dP							dR
F							T
dF							dT
	1 10 100 inf	1 10 100 inf	1 10 100 inf	1 10 100 inf	1 10 100 inf	1 10 100 inf	

Input Device Taxonomy (Card et al)

	Linear			Rotary			
	X	Y	Z	rX	rY	rZ	
P							R
dP							dR
F							T
dF							dT
	1 10 100 inf	1 10 100 inf	1 10 100 inf	1 10 100 inf	1 10 100 inf	1 10 100 inf	

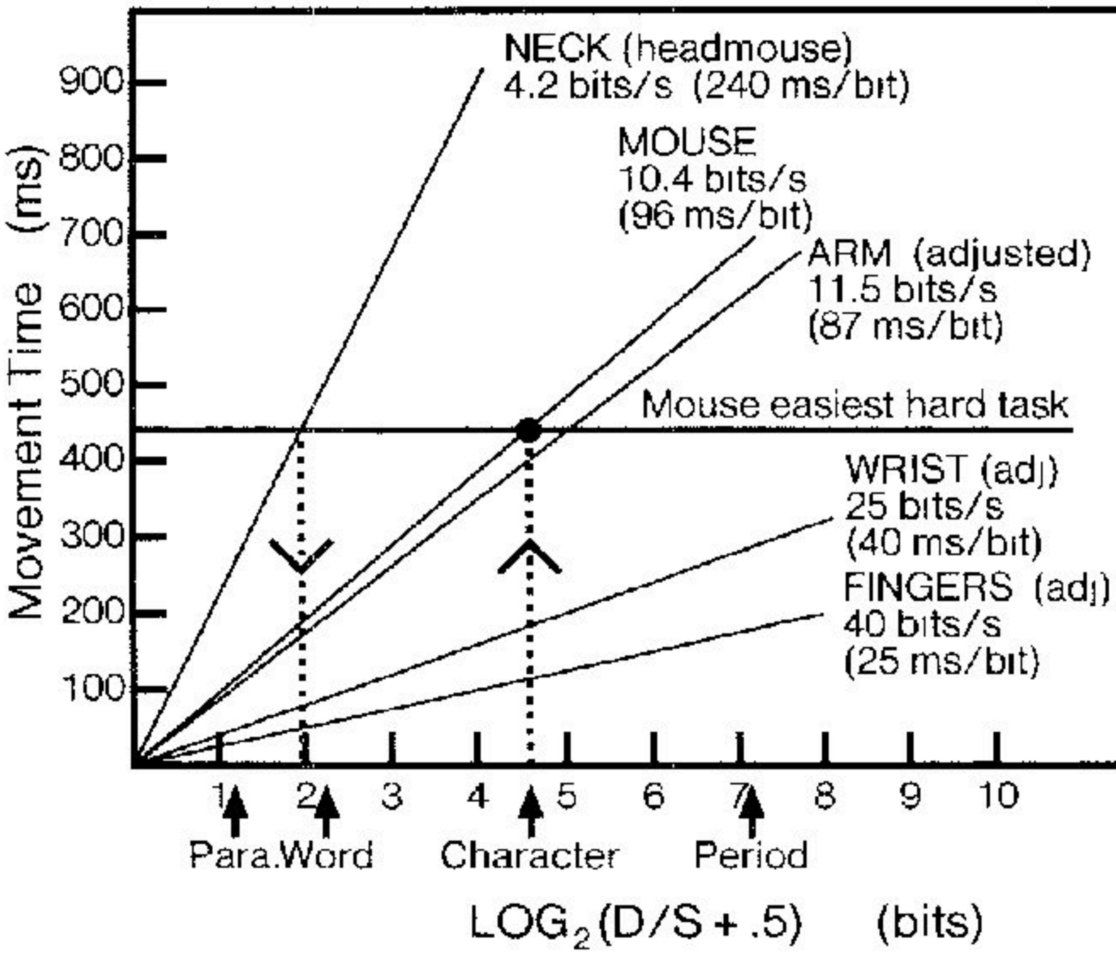
- Example: Touch Screen

Input Device Taxonomy (Card et al)



- Example: Wheel mouse

Movement time for Different Devices / Muscle Groups (Card et al)



3 Capabilities of Humans and Machines

Emotions
Attractive Things Work Better

- Experiment
  - Six ATM identical in function and operation
  - Some aesthetically more attractive than others
  - Result: the nicer ones are easier to use…
- Aesthetics can change the emotional state
  - Emotions allow us to quickly assess situations
  - Positive emotion make us more creative
  - Attractive things make feel people good
  - Relaxed users will more likely forgive design shortcomings
- See D. Norman, Emotional Design (Chapter 1)

Affordance Theory

- Affordance: a situation where an object's sensory characteristics intuitively imply its functionality and use. (www.usabilityfirst.com)
- 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 experience of an individual (Norman)
- Example 1: Hammer and nails
- Example 2: 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

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