CHAPTER 1

THE HUMAN

Lecture Outline

- **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**

INFORMATION-PROCESSING SYSTEM FOR HUMAN

First Part

Information I/O

Human Input/Output Channels

- A person's interaction with the outside world occurs through information being received and sent: input and output.

- In an interaction with a computer:
  - The user receives information that is output by the computer.
  - Responds by providing input to the computer.
  - The user's output becomes the computer's input and vice versa.

Human Input/Output Channels (cont)

- Input in the human occurs mainly through the senses.
- Output through the motor control of the effectors.
- There are five major senses:
  1. Sight
  2. Hearing
  3. Touch
  4. Taste
  5. Smell

Human Input/Output Channels (cont)

- Only sight, hearing, and touch are the most important to HCI.
- Taste and smell do not currently play a significant role in HCI.

- For example, Imagine using a personal computer (PC) with a mouse and a keyboard:
  - The application you are using has a graphical interface, with menus, icons and windows.
  - In your interaction with this system you receive information primarily by sight, from what appears on the screen.

Human Input/Output Channels (cont)

- However, you may also receive information by ear.

- For example, the computer may 'beep' at you if you make a mistake or to draw attention to something, or there may be a voice commentary in a multimedia presentation.

Vision

- Vision is the primary source of information for the average person.
- Human vision is a highly complex activity with a range of physical and perceptual limitations.

- We can roughly divide visual perception into two stages:
  - The physical reception of the stimulus from the outside world.
  - The processing and interpretation of that stimulus.

First Stage: Physical Reception

- Vision begins with light.
- The eye is a mechanism for receiving light and transforming it into electrical energy.
  - Light is reflected from objects in the world.
  - image is focused upside down on the back of the eye (i.e., in retina).
  - The receptors in the eye transform it into electrical signals which are passed to the brain.
  - Ganglion cells (brain!) detect pattern and movement.

Second Stage: Processing and Interpreting

- The visual perception has many aspects which are:
  - Perceiving size and depth
  - Perceiving brightness
  - Perceiving color

- How does the eye perceive size, depth and relative distances?

Perceiving Size and Depth

- As we noted in the previous section, reflected light from the object forms an upside-down image on the retina.
- The size of that image is specified as a visual angle.

Perceiving Size and Depth (cont)

- Visual angle indicates how much of view object occupies (affected by size and distance from eye)
  - if two objects are at the same distance, the larger one will have the larger visual angle.
  - if two objects of the same size are placed at different distances from the eye furthest one will have the smaller visual angle.

- visual acuity is ability to perceive detail (limited).

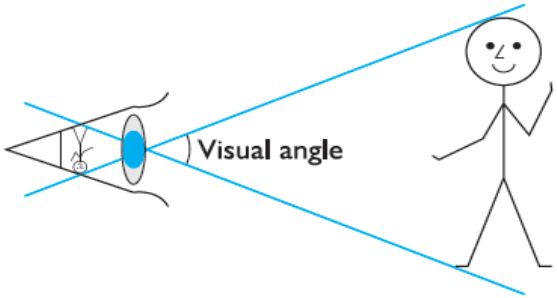
Perceiving Size and Depth (cont)

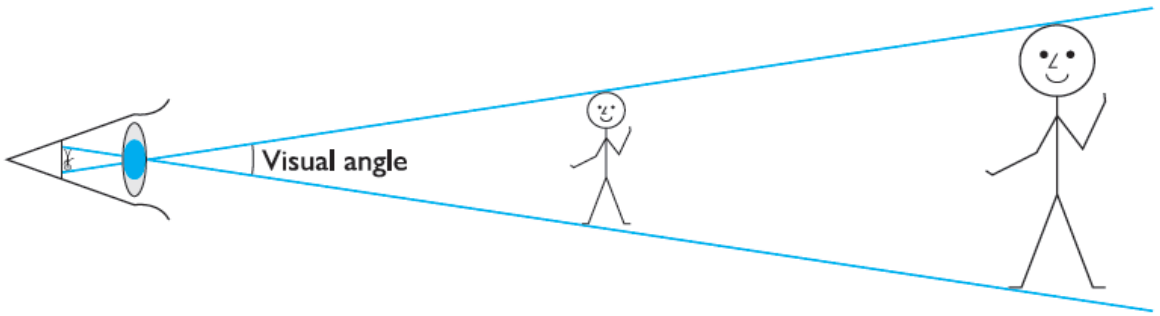
- If we were to draw a line from the top of the object to a central point on the front of the eye and a second line from the bottom of the object to the same point.

- Visual angle of the object is the angle between these two lines.

Perceiving Size and Depth (cont)

- The following figures illustrate how the visual angle is calculated.





Exercise (1)

- How does the eye perceive brightness and color?
  - Send to email : olwan7do@gmail.com

Exercise (1): Info

- 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

Processing and Interpreting (cont)

- The visual system compensates for:
  - movement
  - changes in luminance.

- Context is used to resolve ambiguity.
- Optical illusions sometimes occur due to over compensation.

Visual Processing

- Capabilities and limitations of visual processing:
  - Visual processing involves the transformation and interpretation of a complete image, from the light that is thrown onto the retina (i.e., visual processing enact the high-level of visual perception).
  - Visual processing compensates for the movement of the image on the retina, which occurs as we move around and as the object which we see moves.

Visual Processing (cont)

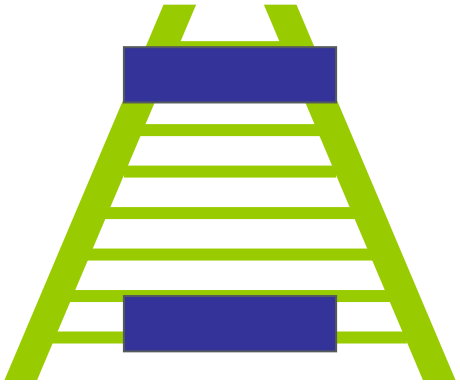
- Capabilities and limitations of visual processing:
  - As an ability to interpret and exploit our expectations.
  - Visual processing can be used to resolve ambiguity.
  - For example, consider the object shown in the following figure.

Visual Processing (cont)

- Capabilities and limitations of visual processing:
  - The context in which the object appears allows our expectations to clearly disambiguate the interpretation of the object, as either a B or a 13.

Visual Processing (cont)

- On the other side, Visual processing can also create optical illusions.
- For example, consider the following Ponzo illusion figure.



the Ponzo illusion

Visual Processing (cont)

- In this figure: the top line appears longer, owing to the distance effect.
- Although both lines are the same length.

- These illusions demonstrate that our perception of size is not completely reliable.

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

- Hearing begins with vibrations in the air or sound waves.
- Ear receives these vibrations and transmits them through various stages, to the auditory nerves.

Hearing (cont)

- 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.

- Humans can hear frequencies from 20Hz to 15kHz
  - less accurate distinguishing high frequencies than low.

Touch

- Provides important feedback about environment.
- May be key sense for someone who is visually impaired.

- Stimulus received via receptors in the skin, has three types of sensory receptor:
  - Thermoreceptors
    - respond to heat and cold
  - Nociceptors
    - respond to pain
  - Mechanoreceptors
    - respond to pressure (some instant, some continuous)

- Some areas more sensitive than others e.g. fingers.

Movement

- Time taken to respond to stimulus.
  - reaction time + movement time
- Movement time dependent on age, fitness etc.
- Reaction time

  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

INFORMATION-PROCESSING SYSTEM FOR HUMAN

Second Part

Information Stored in Memory

Memory

- Memory is the second part of our model of the human as an information-processing system.
- Indeed, much of human everyday activity relies on memory. As well as storing all human factual knowledge.
- Memory contains knowledge of actions or procedures.
- Memory allows human to repeat actions, to use language, and to use new information received via senses.

Memory

- How does human memory work?
  - To answer this question, we need to understand some of the capabilities and limitations of human memory.
- There are three types of memory function:
  - Sensory memories or sensory buffers
    - Attention
  - Short-term memory or working memory
    - Rehearsal
  - Long-term memory
- Selection of stimuli governed by level of arousal.

Memory

A Model for The Structure of The Memory

Sensory Memory

- The sensory memories act as buffers for stimuli received through the senses.
- There is a sensory memory exists for each sensory channel:
  - iconic memory: visual stimuli
    - is the sensory memory for visual stimuli
  - echoic memory: aural stimuli
    - is the sensory memory for aural stimuli
  - haptic memory: tactile stimuli
    - is the sensory memory for touch

Sensory Memory

- For examples
  - "sparkler" trail
  - stereo sound
  - continuously overwritten

- We can demonstrate the existence of iconic memory by moving a finger in front of the eye.
  - Can you see it in more than one place at once?
    - This indicates a persistence of the image after the stimulus has been removed.

Sensory Memory

- Information is passed from sensory memory into short-term memory by attention, thereby filtering the stimuli to only those which are of interest at a given time.
- Attention is the concentration of the mind on one out of a number of competing stimuli or thoughts.
- It is clear that we are able to focus our attention selectively, choosing to attend to one thing rather than another.
  - This is due to the limited capacity of our sensory and mental processes.

Short-Term Memory (STM)

- Short-term memory acts as a 'scratch-pad' for temporary recall (i.e., it is used to store information which is only required fleetingly).

- Also, short-term memory is:
  - rapid access
  - rapid decay
  - limited capacity

Examples

212348278493202

0121 414 2626

HEC ATR ANU PTH ETR EET

Examples

- Calculate the multiplication 35 × 6 in your head. The chances are that you will have done this calculation in stages:
  - Perhaps 5 × 6 and then 30 × 6 and added the results.
  - May be have used the fact that 2 × 3 = 6 and calculated 2 × 35 = 70 followed by 3 × 70.

- To perform calculations such as this we need to store the intermediate stages for use later.

Short-Term Memory (STM)

- Rapid Access ~ 70 ms
  - Short-term memory can be accessed rapidly, in the order of 70 ms.
- Rapid Decay ~ 200 ms
  - Short-term memory also decays rapidly, meaning that information can only be held there temporarily, in the order of 200 ms.
- Limited Capacity ~ 7±2 Chunks
  - Short-term memory also has a limited capacity.

Short-Term Memory (STM)- Limited Capacity

- Short-term memory also has a limited capacity.
- There are two basic methods for measuring memory capacity:
  - The first, involves determining the length of a sequence which can be remembered in order.
  - The second, allows items to be freely recalled in any order.
- In 1956, Miller established experiments which indicate that the average person can remember 7 ± 2 digits.
- For example, try to Look at the following number sequence: 265397620853

Short-Term Memory (STM)- Limited Capacity

- Now write down as much of the sequence as you can remember.
  - Did you get it all right?
  - If not, how many digits could you remember?
  - If you remembered between five and nine digits your digit span is average.
- Now try the following sequence:

  44 113 245 8920
  - Did you recall that more easily?
  - Here the digits are grouped or chunked.
  - A generalization of the 7 ± 2 rule is that we can remember 7 ± 2 chunks of information.
- Therefore, chunking information can increase the short-term memory capacity.

Short-Term Memory (STM)- Design Focus

- Human minds have a tendency to flush short-term memory in order to get on with the next job.
  - Early automatic teller machines (ATMs) gave the customer money before returning their bank card.
  - On receiving the money the customer would reach closure and hence often forget to take the card.
  - Modern ATMs return the card first!

Short-Term Memory (STM)-Design Focus

- We noted the general rule that people can hold 7 ± 2 items or chunks of information in short-term memory.
- It is a principle that people tend to remember but it can be misapplied.
- The 7 ± 2 rule would apply in graphic user interfaces.

- For example, It is often suggested that this means that lists, menus and other groups of items should be designed to be no more than 7 items long.
  - But use of menus and lists of course has little to do with short-term memory.
  - They are available in the environment as cues and so do not need to be remembered.

Short-Term Memory (STM)-Design Focus

- On the other hand the 7 ± 2 rule would apply in command line interfaces.

- For example, Imagine a scenario where a UNIX user looks up a command in the manual:
  - Perhaps the command has a number of parameters of options, to be applied in a particular order, and it is going to be applied to several files that have long path names.
  - The user then has to hold the command, its parameters and the file path names in short term memory while he types them in.
  - Here we could say that the task may cause problems if the number of items or chunks in the command line string is more than 7.

Long-Term Memory (LTM)

- Long-term memory is the store of factual information, experiential knowledge, and procedural rules of behavior (i. e., everything that we 'know').

- Long-term memory is repository for all our knowledge.
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge or unlimited capacity

Long-Term Memory (LTM)

- Long-term memory differs from short-term memory in a number of significant ways. These ways are:
  - It has a huge capacity, if not unlimited.
  - It has a relatively slow access time of approximately a tenth of a second (1/10).
  - Forgetting occurs more slowly in long-term memory. Unlike working memory there is little decay:
    - long-term recall after minutes is the same as that after hours or days.

- Information is placed there (in long-term memory) from working memory through rehearsal

Long-Term Memory (LTM) Structure

- Long-term memory have two types:
  - Episodic memory
    - Episodic memory is represents our memory of events and experiences in a serial form.
  - Semantic memory
    - Semantic memory is a structured record of facts, concepts and skills that we have acquired.

- Semantic LTM derived from episodic LTM
  - The information in semantic memory is derived from that in our episodic memory, (such that we can learn new facts or concepts from our experiences).

Long-Term Memory (cont.) Structure

- Semantic memory is structured in some way to:
  - Provides access to information.
  - Represents relationships between pieces of information.
  - Provides inference.

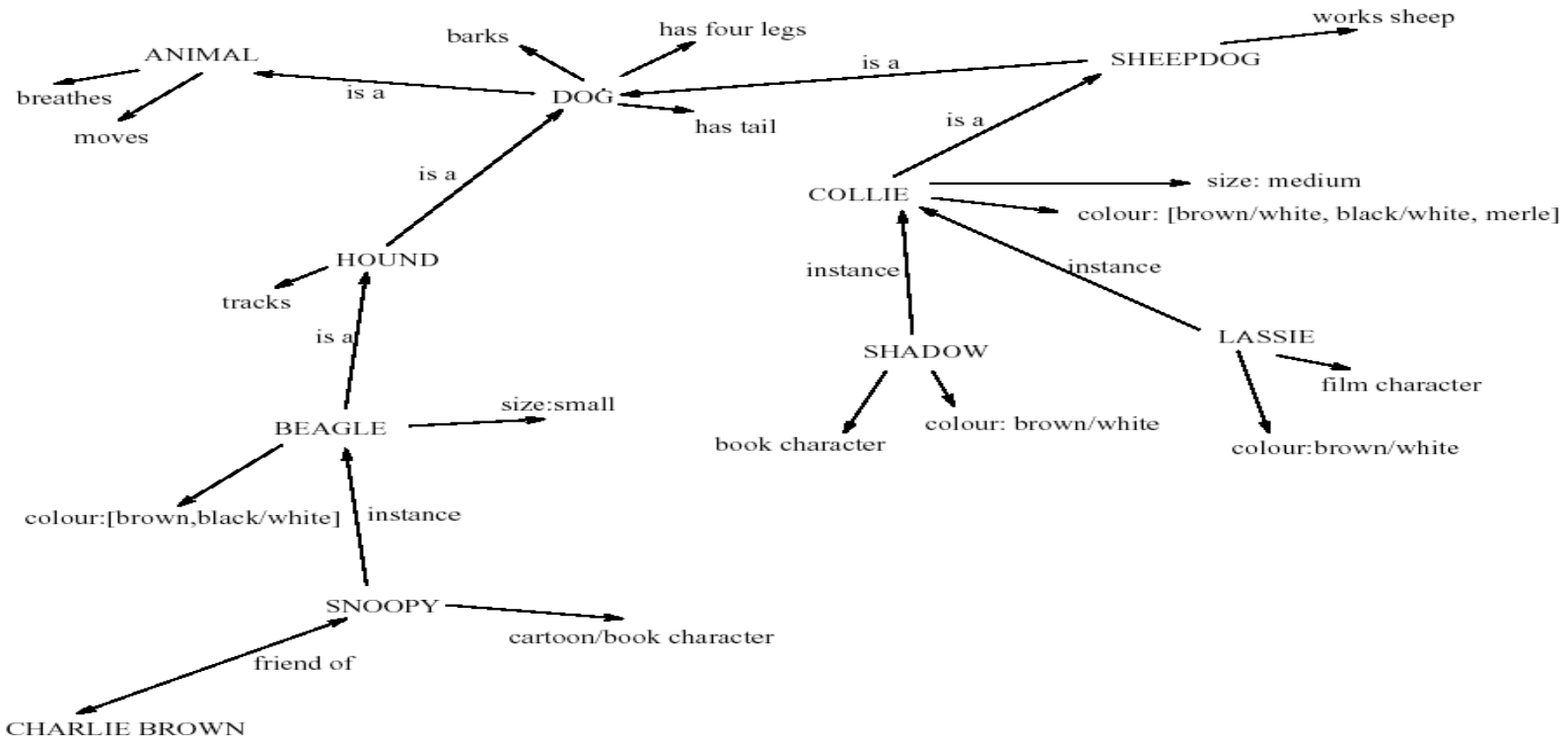
Long-Term Memory (cont.) Structure Model

- One model for the way in which semantic memory is structured is as a network.
- Items are associated to each other in classes, and may inherit attributes from parent classes. This model is known as a semantic network.

- Model: semantic network
  - Inheritance – child nodes inherit properties of parent nodes.
  - Relationships between piece of information explicit.
  - Supports inference through inheritance.

Long-Term Memory (cont.) Structure Model

- Fore example, the knowledge about dogs may be stored in a network such as the following figure.



Long-Term Memory (cont.) Models of LTM - Frames

- There are A number of other memory structures (such as frames and scripts)
- Frames and scripts organize information into data structures.
- Slots in these structures allow attribute values to be added.
- Frame slots may contain default, fixed or variable information.
  - A frame is instantiated when the slots are filled with appropriate values.

- See the following figure.

Long-Term Memory (cont.) Models of LTM - Frames

DOG

Fixed
- legs: 4

Default
- diet: carniverous
- sound: bark

Variable
- size:
- colour

COLLIE

Fixed
- breed of: DOG
- type: sheepdog

Default
- size: 65 cm

Variable
- colour

Figure : Frame-based Representation of Knowledge

Long-Term Memory (cont.) 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*	Roles:	*vet examines* *diagnoses* *treats* *owner brings dog in* *pays* *takes dog out*
Result:	*dog better* *owner poorer* *vet richer*	Scenes:	*arriving at reception* *waiting in room* *examination* *paying*
Props:	*examination table* *medicine* *instruments*	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 …

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

INFORMATION-PROCESSING SYSTEM FOR HUMAN

Third Part

Information Processed and Applied

(Reasoning, Problem Solving, Skill, Error)

Thinking

- Reasoning
  - Deduction
  - Induction
  - Abduction
- Problem solving
- Skill
- Error

Deductive Reasoning

- Deduction is derive logically necessary conclusion from given premises.
- Example:
  - If it is Friday then she will go to work
  - It is Friday
  - Therefore she will go to work.

- Logical conclusion not necessarily true:
- Example:
  - 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 …
- Example:
  - Some people are babies
  - Some babies cry
- Inference - Some people cry
- Correct?

- People bring world knowledge to bear

Inductive Reasoning

- Induction is generalize from cases seen to cases unseen.
- Example:
  - all elephants we have seen have trunks
  - therefore all elephants have trunks.

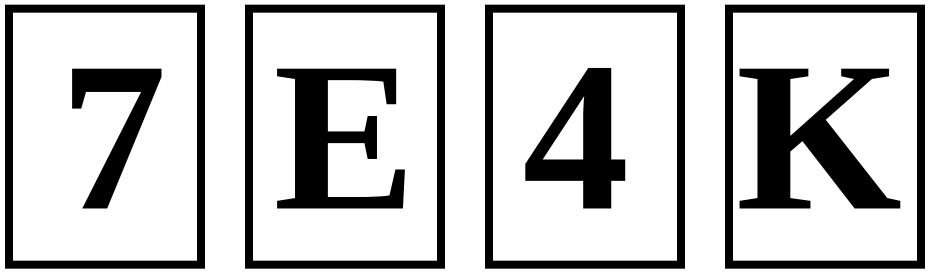
- Unreliable:
  - can only prove false not true

    … but useful!

- Humans not good at using negative evidence

  e.g. Wason's cards.

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

- Abduction is reasoning from event to cause
- Example:
  - Sam drives fast when drunk.
  - If I see Sam driving fast, assume drunk.

- Unreliable:
  - Can lead to false explanations

Problem Solving

- Problem solving is process of finding solution to unfamiliar task using knowledge.

- Several theories:
  - Gestalt theory
    - Problem solving both productive and reproductive.
  - Problem space theory
    - problem space comprises problem states (generating states using legal operators).
    - largely applied to problem solving in well-defined areas "e.g. puzzles".

Errors and mental models

- Types of error:
  - Slips
    - The right intention, but failed to do it right.
    - Causes: poor physical skill and inattention etc.
    - Change to aspect of skilled behaviour can cause slip.
  - Mistakes
    - The wrong intention.
    - Cause: incorrect understanding.
      humans create mental models to explain behaviour.
      if wrong (different from actual system) errors can occur.

INFORMATION-PROCESSING SYSTEM FOR HUMAN

Fourth Part

Emotion Influences Human Capabilities

Emotion

- Various theories of how emotion works:
  - Emotion is our interpretation of a physiological response to a stimuli(James-Lange).
  - Emotion is a psychological response to a stimuli (cannon).
  - Emotion is the result of our evaluation of our physiological responses, in the light of the whole situation we are in (schacter-singer).

- 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
  - intellectual abilities
- Short term
  - effect of stress
  - effect of 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
    $\Rightarrow$ blue should not be used for important detail

- However, correct application generally requires:
  - understanding of context in psychology.
  - understanding of particular experimental conditions.

Questions

?