Overview:

- Humans are limited in their capacity to process information. This has important implications for design.
- Information is received and responses given via a number of input and output channels:
  - visual channel
  - auditory channel
  - haptic channel
- Information is stored in memory:
  - sensory memory
  - short-term (working) memory
  - long-term memory
- Information is processed and applied:
  - reasoning
  - problem solving
- Emotion influences human capabilities.
- Users share common capabilities but are individuals with differences, which should not be ignored.

The requirements of the user should therefore be our first priority. In this lecture we will look at areas of human psychology coming under the general banner of *cognitive psychology (***is a sub-discipline of psychology exploring internal mental processes. It is the study of how people perceive, remember, think, speak, and solve problems***)*. This may seem a far cry from designing and building interactive computer systems, but it is not. In order to design something for someone, we need to understand their capabilities and limitations.

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, and responds by providing input to the computer – the user's output becomes the computer's input and vice versa.

Input in the human occurs mainly through the senses and output through the motor control of the effectors. **There are five major senses: sight, hearing, touch, taste and smell. Of these, the first three are the most important in HCI.**

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. However, you may also receive information by ear: for example, the computer may 'beep' at you if you make a mistake. You yourself send information to the computer using your hands, either by hitting keys or moving the mouse. Sight and hearing do not play a direct role in sending information in this example, although they may be used to receive **information from a third source (for example, a book, or the words of another person)** which is then transmitted to the computer.

1. ***Visual perception*:**

   1.1. *Perceiving size and depth*

   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, the visual angle of the object is the angle between these two lines. Visual angle is affected by both the size of the object and its distance from the eye. Therefore if two objects are at the same distance, the larger one will have the larger visual angle.

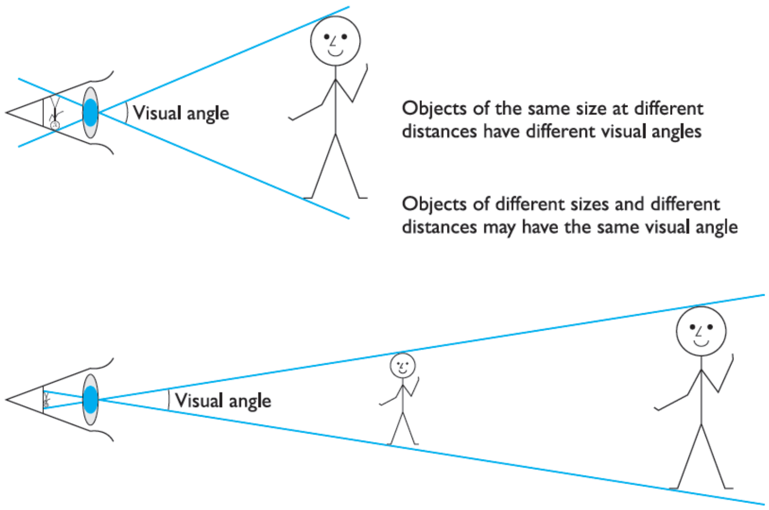

Figure 1: Visual Angel

   1.2. *Perceiving brightness:* A second aspect of visual perception is the perception of *brightness*. Brightness is in fact a subjective reaction to levels of light. It is affected by ***luminance*** which is the amount of light emitted by an object.

   1.3. *Perceiving color:* A third factor that we need to consider is perception of color.

2. ***Hearing***: sound can convey a remarkable amount of information. It is rarely used to its potential in interface design, usually being confined to warning sounds and notifications. The exception is multimedia, which may include music, voice commentary and sound effects. However, the ear can differentiate quite subtle sound changes and can **recognize** familiar sounds without concentrating attention on the sound source. This suggests that sound could be **used more extensively in interface design**, to convey information about the system state, for example.

3. ***Touch***: a touch or *haptic perception*, although this sense is often viewed as less important than sight or hearing, imagine life without it. Touch provides us with vital information about our environment.

HUMAN MEMORY

Memory is the second part of our model of the human as an information-processing system.

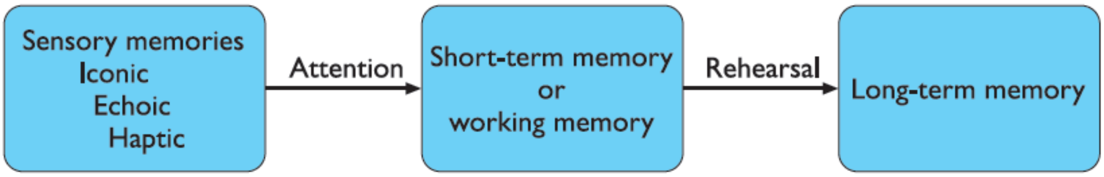

Figure 2: a Model of a Structure of Memory

1. Sensory memory: The sensory memories act as buffers for stimuli received through the senses. A sensory memory exists for each sensory channel: *iconic memory* for visual stimuli, *echoic memory* for aural stimuli and *haptic memory* for touch. These memories are constantly overwritten by new information coming in on these channels.
2. Short-term memory: Short-term memory or working memory acts as a 'scratch-pad' for temporary recall of information. It is used to store information which is only required fleetingly. For example, 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; or you may have used the fact that 6 = 2 × 3 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. Or consider reading. In order to comprehend this sentence you need to hold in your mind the beginning of the sentence as you read the rest. Both of these tasks use short-term memory.
3. Long-term memory if short-term memory is our working memory or 'scratch-pad', long-term memory is our main resource. Here we store factual information, experiential knowledge, and procedural rules of behavior – in fact, everything that we 'know'. It differs from short-term memory in a number of significant ways. **First**, it has a huge, if not unlimited, capacity. **Secondly**, it has a relatively slow access time of approximately a tenth of a second. **Thirdly**, forgetting occurs more slowly in long-term memory, if at all. These distinctions provide further evidence of a memory structure with several parts. Long-term memory is intended for the long-term storage of information. Information is placed there from working memory through rehearsal. Unlike working memory there is little decay: long-term recall after minutes is the same as that after hours or days.

THINKING: REASONING AND PROBLEM SOLVING

Humans, on the other hand, are able to use information to reason and solve problems, and indeed do these activities when the information is partial or unavailable. Human thought is conscious and self-aware:

while we may not always be able to identify the processes we use, we can identify the products of these processes, our thoughts. In addition, we are able to think about things of which we have no experience, and solve problems which we have never seen before. How is this done?

We will consider two categories of thinking: **reasoning and problem solving**. In practice these are not distinct since the activity of solving a problem may well involve reasoning and vice versa.

1. Reasoning

Reasoning is the process by which we use the knowledge we have to draw conclusions or infer something new about the domain of interest. There are a number of different types of reasoning: *deductive* and *inductive*. We use each of these types of reasoning in everyday life, but they differ in significant ways.

Deductive reasoning

Deductive reasoning derives the logically necessary conclusion from the given premises. For example,

If it is Friday then she will go to work

It is Friday

Therefore she will go to work.

It is important to note that this is the *logical* conclusion from the premises; it does not necessarily have to correspond to our notion of truth. So, for example,

If it is raining then the ground is dry

It is raining

Therefore the ground is dry.

Is a perfectly valid deduction, even though it conflicts with our knowledge of what is true in the world. Deductive reasoning is therefore often misapplied. Given the premises

Some people are babies

Some babies cry

Many people will infer that 'Some people cry'. This is in fact an invalid deduction since we are not told that all babies are people. It is therefore logically possible that the babies who cry are those who are not people.

Inductive reasoning

Induction is generalizing from cases we have seen to infer information about cases we have not seen. For example, if every elephant we have ever seen has a trunk, we infer that all elephants have trunks. Of course, this inference is unreliable and cannot be proved to be true; it can only be proved to be false. We can disprove the inference simply by producing an elephant without a trunk. However, we can never prove it true because, no matter how many elephants with trunks we have seen or are known to exist, the next one we see may be trunkless. The best that we can do is gather evidence to support our inductive inference. In spite of its unreliability, induction is a useful process, which we use constantly in learning about our environment.

2. Problem solving

If reasoning is a means of inferring new information from what is already known, problem solving is the process of finding a solution to an unfamiliar task, using the knowledge we have. Human problem solving is characterized by the ability to adapt the information we have to deal with new situations. However, often solutions seem to be original and creative. There are a number of different views of how people solve problems. The earliest, dating back to the first half of the twentieth century, is the *Gestalt* view that problem solving involves both reuse of knowledge and insight. This has been largely superseded but the questions it was trying to address remain and its influence can be seen in later research. A second major theory, proposed in the 1970s by Newell and Simon, was the *problem space theory*, which takes the view that the mind is a limited information processor. Later variations on this drew on the earlier theory and attempted to reinterpret Gestalt theory in terms of information processing theories. We will look briefly at each of these views.

1. *Gestalt theory*

Gestalt psychologists were answering the claim, made by behaviorists, that problem solving is a matter of reproducing known responses or trial and error. This explanation was considered by the Gestalt school to be insufficient to account for human problem-solving behavior. Instead, they claimed, problem solving is both *productive* and *reproductive*. Reproductive problem solving draws on previous experience as the behaviorists claimed, but productive problem solving involves insight and restructuring of the problem. Indeed, reproductive problem solving could be a hindrance to finding a solution, since a person may 'fixate' on the known aspects of the problem and so be unable to see novel interpretations that might lead to a solution.

Gestalt psychologists backed up their claims with experimental evidence.

Although Gestalt theory is attractive in terms of its description of human problem solving, it does not provide sufficient evidence or structure to support its theories.

2. *Problem space theory*

Newell and Simon proposed that problem solving centers on the problem space. The problem space comprises *problem states*, and problem solving involves generating these states using legal state transition operators. The problem has an initial state and a goal state and people use the operators to move from the former to the latter. Such problem spaces may be huge, and so *heuristics* are employed to select appropriate operators to reach the goal. One such heuristic is *means–ends analysis*. In means–ends analysis the initial state is compared with the goal state and an operator chosen to reduce the difference between the two. For example, imagine you are reorganizing your office and you want to move your desk from the north wall of the room to the window. Your initial state is that the desk is at the north wall. The goal state is that the desk is by the window. The main difference between these two is the location of your desk.

EMOTION

Psychologists have studied emotional response for decades and there are many theories as to what is happening when we feel an emotion and why such a response occurs.

More than a century ago, William James proposed what has become known as the James–Lange theory (Lange was a contemporary of James whose theories were similar): that emotion was the interpretation of a physiological response, rather than the other way around. So while we may feel that we respond *to* an emotion, James contended that we respond physiologically to a stimulus and interpret that as emotion:

Common sense says we lose our fortune, are sorry and weep; we meet a bear, are frightened and run; we are insulted by a rival, are angry and strike. The hypothesis here . . . is that we feel sorry because we cry, angry because we strike, afraid because we tremble. (W. James, *Principles of Psychology*, page 449. Henry Holt, New York, 1890.)

Others, however, disagree. Cannon, for example, **argued that our physiological processes are in fact too slow to account for our emotional reactions**, and that the physiological responses for some emotional states are too similar (e.g. anger and fear), yet they can be easily distinguished. Experience in studies with the use of drugs that stimulate broadly the same physiological responses as anger or fear seems to support this: participants reported physical symptoms but not the emotion, which suggests that emotional response is more than recognition of physiological changes.

INDIVIDUAL DIFFERENCES

We should be aware of individual differences so that we can account for them as far as possible within our designs. These differences may be long term, such as sex, physical capabilities and intellectual capabilities. Others are shorter term and include the effect of stress or fatigue on the user. Still others change through time, such as age.

These differences should be taken into account in our designs. It is useful to consider, for any design decision, if there are likely to be users within the target group who will be adversely affected by our decision.