Design of Interactive Systems (DIS)

Lecture 11: Foundations of designing interactive systems– Memory and attention

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Part IV Foundations of designing interactive systems

- **Chapter 21**: Memory and attention
- **Chapter 22**: Affect
- **Chapter 23**: Cognition and action
- **Chapter 24**: Social interaction
- **Chapter 25:** Perception and navigation

Introduction

- Memory and attention are two key abilities that people have.
- They work together to enable us to act in the world.
- For interactive systems designers there are some key features of memory and attention that provide important background to their craft.

Aims

- The importance of memory and attention and their major components and processes.
- Attention and awareness; situation awareness, attracting and holding attention.
- The characteristics of human error and mental workload and how it is measured.

Introduction

- **Memory** is one of the main components of a psychological view of humans that aims to explain **how we think** and **act**.
- There are several key issues about memory. First, it is not just a single, simple information store - it has a complex, and still argued over, structure.
- **Short-term memory** is very limited but is useful for holding such things as telephone numbers while we are dialing. Stores small amount of information in an active state for a short period of time.
- **Long-term memory** stores, fairly reliably, things such as our names and other biographical information. Stores larger amount of information lasting from few minutes to a lifetime.

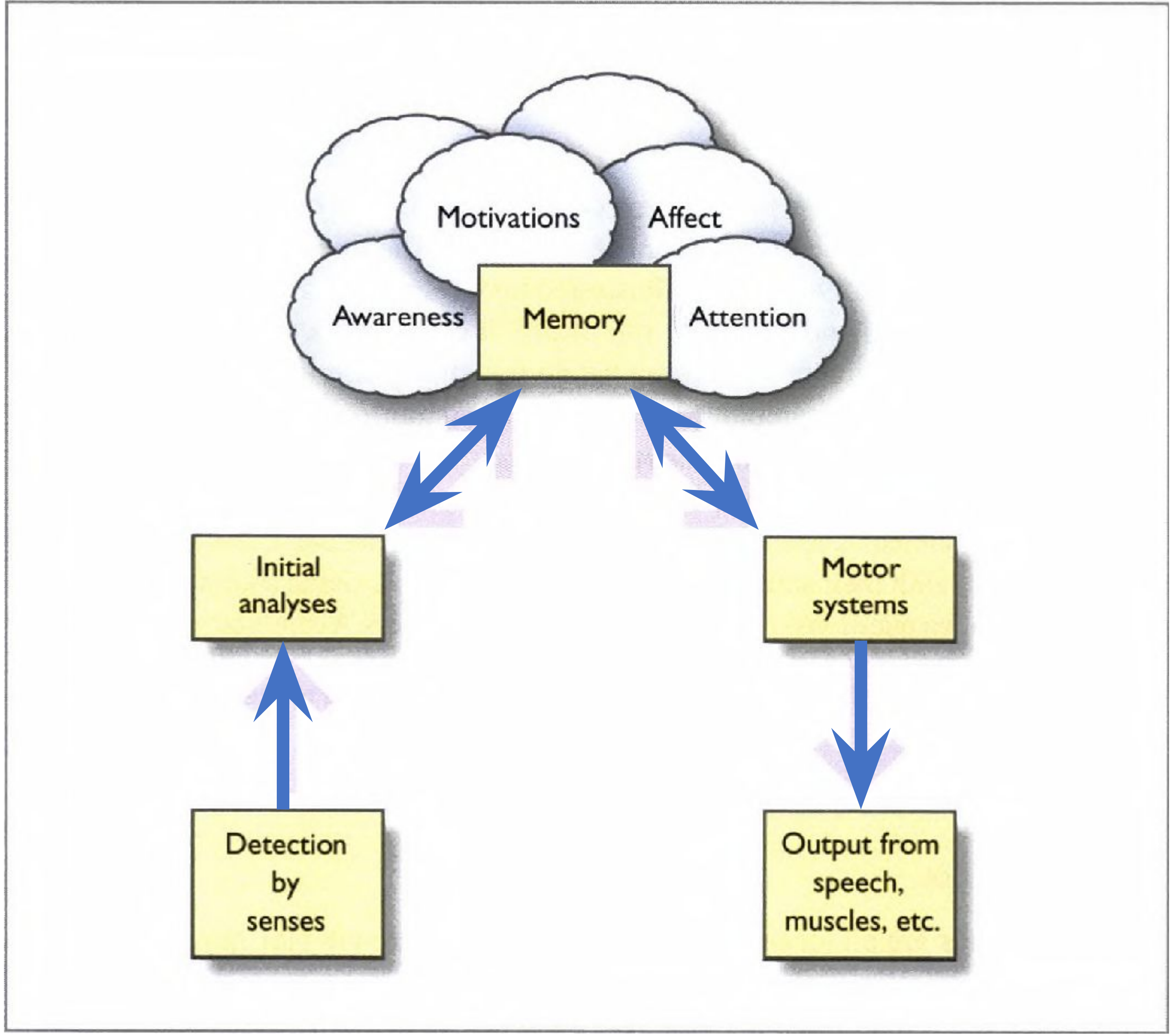


Figure 21.1 A more detailed information processing paradigm

Introduction

- Memory is **not a passive repository**. Memory is **enhanced by deeper** or richer processing of the material to be remembered.
- Memory is also affected by the very nature of the material to be remembered.
- Words, names, commands or images for that matter which are not particularly distinctive will tend to interfere with their subsequent recognition and recall.

Introduction

- **Object recognition** relies on memory; the production and understanding of language relies on some form of internal dictionary;
- **Finding our way about town** relies on an internal representation of the environment, sometimes described as a cognitive map
- Memory is related to attention and these two are related to making mistakes, having accidents or doing things unintentionally

Memory stores: working memory

- Working memory is made up from three linked components, namely a **central executive,** an **articulatory loop** and a **visuo-spatial sketchpad.**
- The **central executive** is involved in decision making, planning and related activities.
- The **articulatory or phonological loop** can be thought of as behaving like a loop of audio tape.
- When we are trying to dial an unfamiliar telephone number or repeating a phrase in a foreign language, we tend to repeat the string of numbers. This process is called **rehearsal**
- When we are doing this we are making use of the **articulatory loop**, which can also account for our experience of the **inner voice.**
- The **visuo-spatial sketchpad** is the visual and spatial information equivalent of the articulatory loop and has been linked to our **mind's eye.**

Memory stores: long-term memory

- Long-term memory has an **effectively unlimited capacity** and memories stored there may last as long as an individual's lifetime.
- The coding (the internal representation) of the information is stored in terms of its meaning, **Semantic memory**
- Memories of music or the bark of a dog are encoded as auditory information,
- Haptic (touch) encoding allows us to remember the feeling of silk and the sting of a cut
- Olfactory (smell) and gustatory (taste) encoding allows us to recognize and distinguish between the smell and taste of fresh and rotten food.

Memory stores: long-term memory

- long-term memory includes other kinds of memories such as **episodic** or **autobiographical** memory, e.g. graduation day, the death of a parent
- **procedural memory** (e.g. the knowledge of how to ride a bike, type, play the euphonium).

How do we remember?

- For example, an apparently random string of numbers such as 00441314551234 may defeat most people unless it is chunked
  - international calls (0044)
  - the area code for Edinburgh (131)
  - the prefix for Edinburgh Napier University (455)
  - leaving only 1234 to remember

How do we remember?

- We are able to retrieve stored information by way of **recall** and/or **recognition.**
- **Recall** is the process whereby individuals actively search their memories to **retrieve** a particular piece of information.
- **Recognition** involves searching our memory and then deciding whether the **piece of information matches** what we have in our memory stores

How and why do we forget?

- There are two key distinction, namely the difference between **accessibility** and **availability**
- **Accessibility** refers to whether or not we are able to *retrieve information* that has been stored in memory
- **Availability** of a memory depends on whether or not it was stored in memory.

How and why do we forget?

- The metaphor of a library is used to illustrate this difference. Imagine you are trying to find a specific book in a library. There are three possible outcomes:
    a. you find the book (**the memory is retrieved**);
    b. the book is not in the library (**the memory is not available**); or
    c. the book is in the library but has been misfiled (**not accessible**).
- **Availability** is the main issue for **working memory** while **accessibility** is the main problem for **long-term memory**.

Forgetting from working memory

- The first and perhaps oldest theory is **decay theory,** which argues that memory simply fades with time
- A point which is particularly relevant to working memory which maintains memories for only 30 seconds or so without rehearsal.

Forgetting from long-term memory

- We become less proficient in a foreign language learned at school if we never use it
- Perhaps memory engrams (= memory traces) **simply fade with time**, but except in cases of explicit neurological damage such as Alzheimer's disease
- **Interference theory** suggests that forgetting is more strongly influenced by what we have done before or after learning than the passage of time itself. Interference takes two forms: **retroactive interference** (RI) and **proactive interference** (PI)

Forgetting from long-term memory

- **Retroactive interference**, as the name suggests, works backwards. That is, newer learning interferes with earlier learning. For example, manual-shift and automatic car
- **Proactive interference** may be seen in action in, for example, moving from word processor vl to v2. Version 2 may have added new features and reorganized the presentation of menus. Having learned version 1 interferes with learning version 2.

Attention

- Attention is a pivotally important human ability and is central to operating a machine, using a computer, driving to work or catching a train.
- Failures in attention are a frequently cited reason for accidents:
- car accidents have been attributed to the driver using their mobile phone while driving; aircraft have experienced ‘controlled flight into terrain’ (to use the official jargon) when the pilots have paid too much attention to the ‘wrong’ cockpit warning

Attention

- Attention is an aspect of cognition that is particularly important in the design and operation of safety-critical interactive systems
- Attention has been split between two basic forms, namely **selective attention** and **divided attention**

Attention

- **Selective attention** refers to our ability to focus on the most important information when there are other distractions.
- Example: Reading a book in a noisy coffee shop.
- **Divided attention** recognizes that attention can be divided between tasks being performed simultaneously (multi-tasking).
- Example: Cooking a meal while talking to someone.

The Stroop effect

Stroop (1935) showed that if a colour word such as 'green' is written in a conflicting colour such as red, people find it remarkably difficult to name the colour the word is written in. The reason is that reading is an automatic process which conflicts with the task of naming the colour of the 'ink' a word is written in. The Stroop effect has also been shown to apply to suitably organized numbers and words.

Try saying aloud the colour of the text – not the word itself:

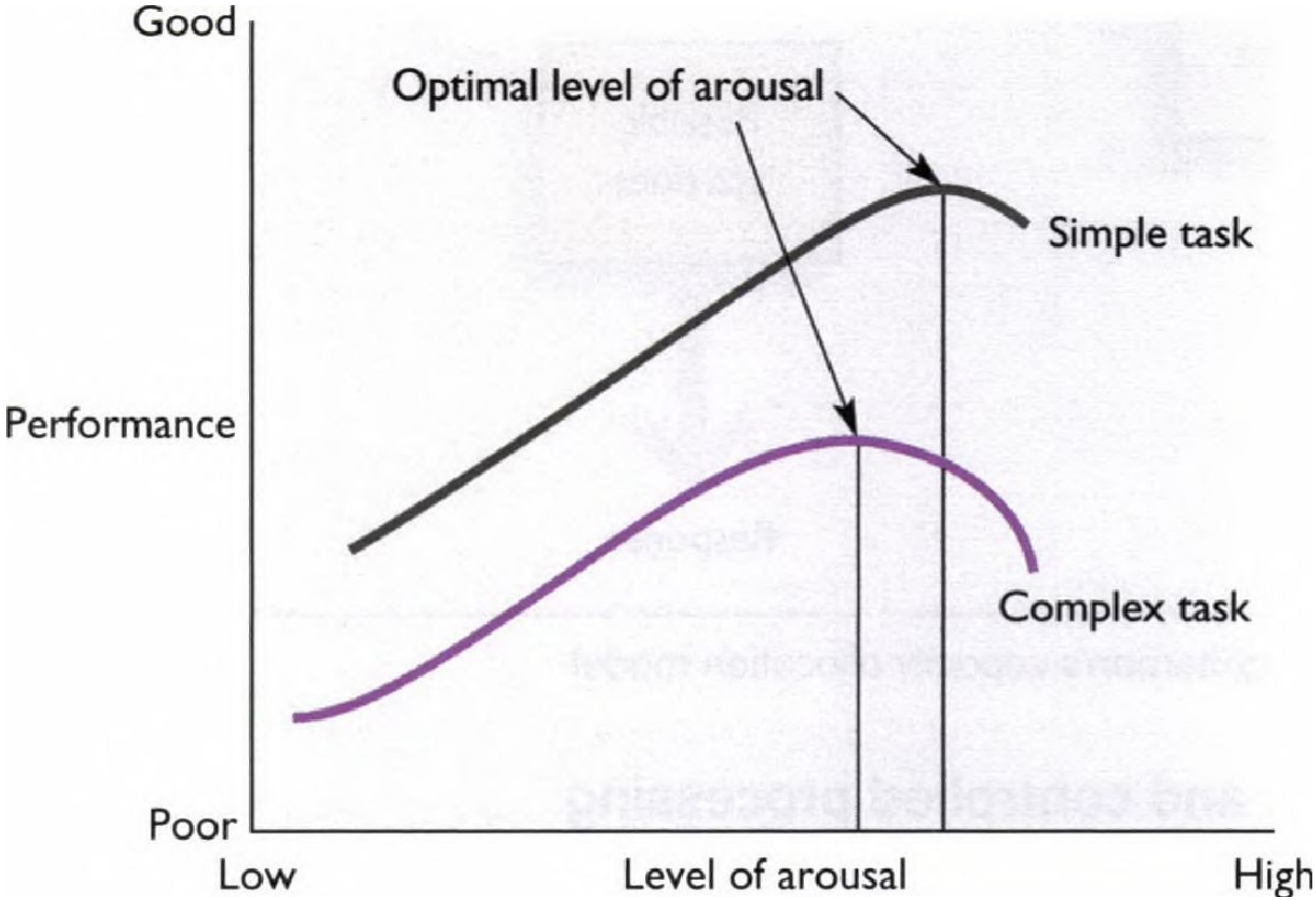
Column 1	*Column 2*
RED	RED
GREEN	GREEN
BLUE	BLUE
RED	RED
GREEN	GREEN
RED	RED

You should find that saying the *colour* of each word in column 1 is slower and more prone to error owing to the meaning of the word itself. The word 'red' interferes with the colour (green) it is printed in and vice versa.

Factors affecting attention

- Of the factors that **affect our ability** to pay attention to a task, **stress** is the most important.
- Stress is the effect of external and psychological stimuli on us and directly affects our level of arousal.
- Arousal may be thought of how awake we are.
- **Stressors** (stimuli which cause stress) include such things as noise, light, vibration (e.g. flying through turbulence) and more psychological factors such as anxiety, fatigue, anger, threat, lack of sleep and fear

The Yerkes-Dodson law



Vigilance

- **Vigilance** is a term applied to the execution of a task wherein an individual is required to monitor an instrument
- vigilance is still an important element of many jobs - consider the **role of the operator** of a **luggage X-ray machine** at an airport, or a safety inspector checking for cracks or loose fittings on a railway track.

Mental workload

- **Mental workload** refers to the cognitive effort required to perform tasks.
- It is a ratio between task complexity and a person's cognitive capacity to meet task demands.
- There are a number of different ways in which workload can be estimated, one of which is the NASA TLX scale.

Table 21.2 Measuring workload

Title	Endpoints	Description
Mental demand	Low/end	How much mental and perceptual activity was required (e.g. thinking, deciding, etc.)? Was the task easy or demanding, simple or complex?
Physical demand	Low/high	How much physical effort was required (e.g. pushing, pulling, etc.)? Was the task easy or demanding, slack or strenuous, restful or laborious?
Temporal demand	Low/high	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
Performance	Perfect/failure	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
Effort	Low/high	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Frustration level	Low/high	How insecure, discouraged, irritated, stressed and annoyed as opposed to secure, gratified, content, relaxed and complacent did you feel during your task?

Visual search

- Visual search refers to our ability to locate particular items in a visual scene.

E	E	E	E	E	E	E	E
E	E	E	E	E	E	E	E
E	E	E	E	E	E	E	E
E	E	E	E	E	E	E	E
E	E	E	E	E	E	E	E
E	E	E	E	E	E	E	E
E	E	E	E	E	E	F	E
E	E	E	E	E	E	E	E

Figure 21.6 A matrix of letters

Visual search

- understanding of the issues involved in visual search can help in avoiding interactive systems such as that shown in Figure

Figure 21.7 A practical example of the challenge of visual search

Visual search

- Visual search **cannot be presumed** to be left to right, or clockwise rather than anti-clockwise,
- visual attention will be drawn towards features **which are large** and **bright** and **changing** (e.g. flashing, which may be used for warnings).
- Displays or dials organized in rows tended to be scanned **from left to right** (just as in reading Western languages, but raising the question of cultural bias)
- Operators tended to concentrate on the centre of the display panel and tended to ignore the periphery.

Just how long is it reasonable to wait?

It is generally accepted that delays of less than 0.1 second are taken to be effectively instantaneous, but delays of a second or two may be perceived by the user of an interactive system as being an interruption in the free flow of his or her interaction. Delays of more than 10 seconds present problems for people. Minimizing delay is important in the design of websites for which numerous, often contradictory, guidelines have been published. Here are two perfectly reasonable suggestions:

- The top of your page should be meaningful and fast.
- Simplify complex tables as they display more slowly.

Signal detection theory

- It is late at night. You are asleep alone in your apartment. You are awoken by a noise. What do you do? For many people the first thing to do is to wait and see (as it were) whether they hear the noise again.
- Here we are in the domain of **signal detection theory -** was there really a signal (e.g. the sound of breaking glass by the local axe-murderer) and if so, are we to act on it - or was it just the wind or a cat in the dustbin?
- Signal detection theory (SDT) is applicable in any situation in which there are two different, non-overlapping states (i.e. signal and noise) that cannot be easily discriminated

Signal detection theory

- In such situations we are concerned with signals **which must be detected**, and in the process one of two responses may be produced - e.g. ‘I detected the presence of a signal, so I shall press the stop button’, or ‘I failed to see anything, so I shall continue to watch’
- the detection of a concealed weapon by an airport security guard; the identification of a malignant tumour on an X-ray plate by a radiologist; and a system malfunction detected by a nuclear plant supervisor

Human error

- Human error is studied in many ways. Conducting laboratory investigations or investigating the causes of major accidents after the event.
- A typical example of a laboratory study is that by Hull *et al.* (1988) who asked 24 ordinary men and women to wire an electric plug. They found that only 5 succeeded in doing so safely, despite the fact that 23 of the 24 had wired a plug in the previous 12 months.
- It was found that a number of different factors contributed to these failures, including:
  - Failure to read the instructions.
  - Inability to formulate an appropriate mental model.
  - Failure of the plug designers to provide clear **physical constraints** on erroneous actions. This last point was regarded as the **most significant**.

Understanding action slips

- Research conducted by Reason (1992) has given insight into everyday errors.
- In one study he asked 36 people to keep a **diary of action slips** (i.e. actions which have deviated from what they intended) for a period of four weeks.
- Analysis of the reported 433 slips revealed that **storage failures** (e.g repeating an action which has already been completed) were the most frequently reported.

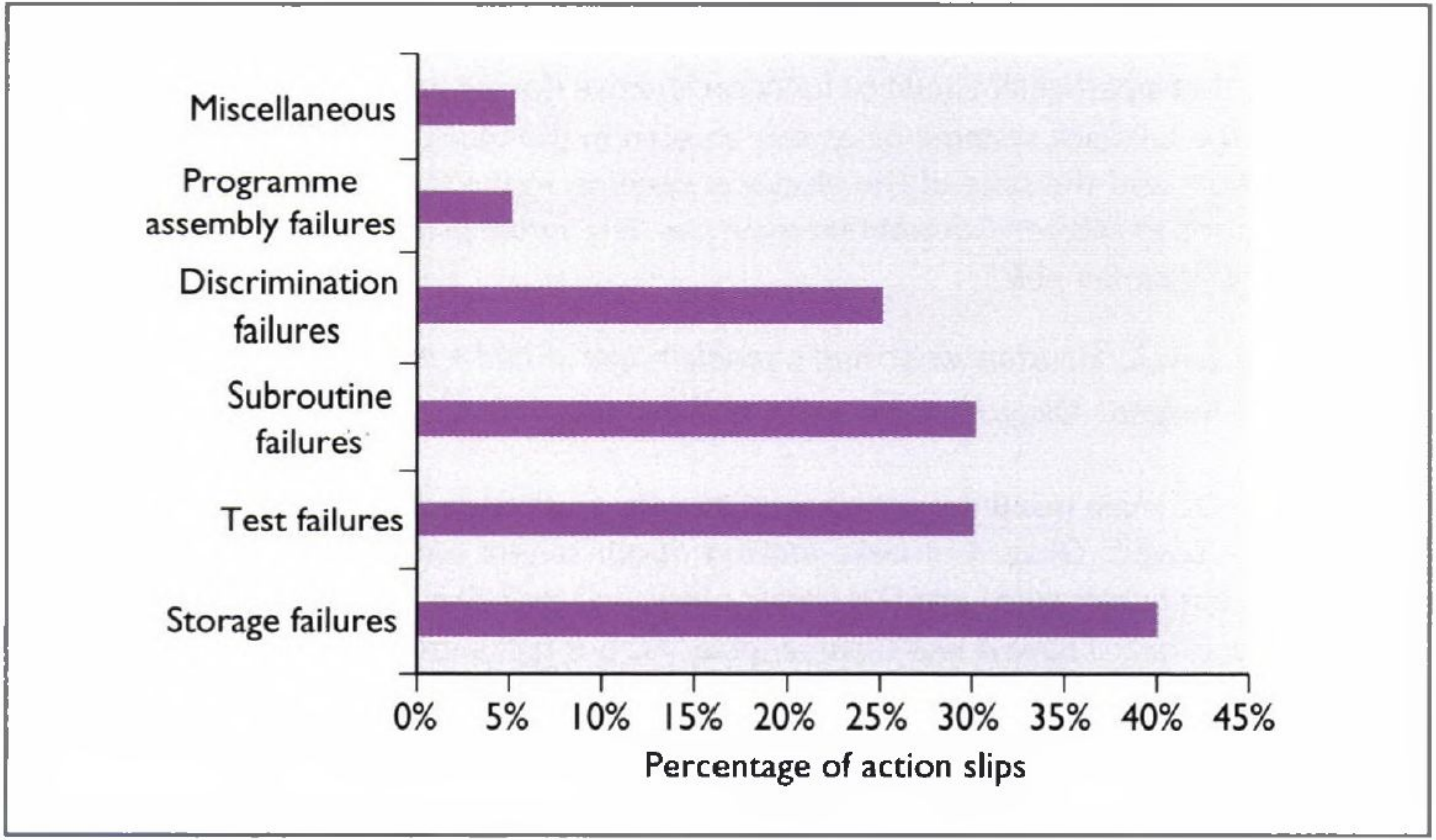


Figure 21.9 Five categories of action slips

Table 21.4 Action slips

Type of action slip	Description
Storage failures	These were the most common and involved errors such as repeating an action which has already been completed, e.g. sending the same e-mail twice.
Test failures	These refer to forgetting what the goal of the action was, owing to failing to monitor the execution of a series of actions, e.g. starting to compose an e-mail and then forgetting to whom you are sending it.
Subroutine failures	These errors were due to omitting a step in the sequence of executing an action, e.g. sending an e-mail and forgetting to attach the attachment.
Discrimination failures	Failure to discriminate between two similar objects used in the execution of an action resulted in this category of error, e.g. intending to send an e-mail and starting Word instead by mistake.
Programme assembly failures	This was the smallest category, accounting for only 5 per cent of the total. They involved incorrectly combining actions, e.g. saving the e-mail and deleting the attachment instead of saving the attachment and deleting the e-mail.

Reducing action slips

- Designers should design to minimize the chance of slips.
- “wizards’ prompt people for, and help them recall, the steps which need to be undertaken to complete a task, such as installing a printer.

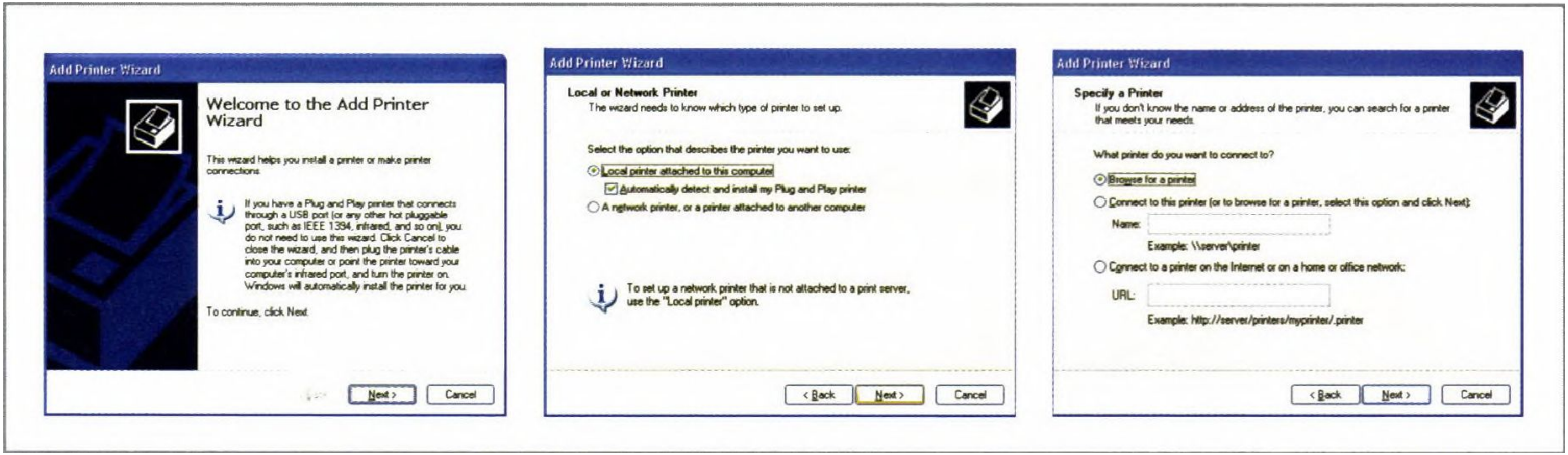


Figure 21.10 Using a Microsoft wizard to prompt a user to supply information one step at a time