Memory

11

CHAPTER OUTLINE

Learning Objectives

By the end of this chapter you should appreciate that:

- memory plays a role in comprehension, language, perception, social relationships and many other aspects of life;
- memory of a past event or information is indicated whenever the event or information influences someone's thoughts, feelings or behaviour at some later time;
- there is an important difference between 'aware' and 'unaware' forms of memory;
- we can observe memory in many different ways – through free recall, cued recall, recognition, familiarity and other behavioural changes, such as priming;
- there is evidence that different sorts of memories can be influenced differently by specific manipulations or variables;
- rather than creating a veridical copy of a past event, remembering involves the active reconstruction of the event or information;
- mnemonic strategies can help us learn and remember information.

INTRODUCTION

You have undoubtedly seen thousands of pennies in your lifetime. Without looking at a coin, take a few seconds to sketch the front of a penny. Do not be tempted to look at a penny – spend a moment or two trying to remember and making a sketch.

Now compare your drawing with an actual penny. How accurate was your memory? Was the head facing the right way? How many of the words did you recall, and did you put them in the right place?

Nickerson and Adams (1979) and Morris (1988) found that most people have very poor memories for very familiar things – like pennies. Why might this be?

This chapter gives a sense of why memory and its study are central to psychology, and always have been. Memory can be studied in many fascinating ways, from laboratory research on nonsense syllables to studies of everyday memory, including autobiographical memory and eyewitness testimony. The extensive research has led to the proposal of several key models of how memory works.

We explore all of these issues in this chapter, which illustrates the richness and diversity of psychological research and why memory is such an important topic for the field of psychology.

WHAT IS MEMORY?

Much more than conscious remembering

To a psychologist, memory is far more than simply bringing to mind information encountered at some previous time. Whenever the experience of some past event influences someone at a later time, the influence of the previous experience is a reflection of memory for that past event.

It is easy to see the role of memory in the case of a student who attends a lecture and later brings to mind what was taught. It may be less obvious that memory still plays a role even when the person does not 'remember' the lecture or the information, but merely uses information from the lecture, possibly without thinking about the lecture itself or the specific information at all.

There are even more subtle and less obvious effects of memory. If the same student later develops an interest (or a marked disinterest) in the topic of the lecture, that interest may reflect memory for the earlier lecture, even though the student might not be able to recall having ever attended a lecture on that topic. Memory plays a role to the degree that the student's attitudes about the topic were influenced by the lecture.

In the same vein, memory plays a role whether or not we intended to learn during the 'past event'. In reality, comparatively little of our time is spent trying to 'record' events for later remembering; most of the time we are simply getting on with life. But past events only have to influence our thoughts, feelings or behaviour to provide evidence of our memory for them.

Just as memory is not dependent upon an intention to record events, it also plays a role regardless of our intention to recall or draw upon those past events. Many of the influences of past events are unintentional; indeed, they may even be quite counter to our intentions (e.g. Jacoby, Woloshyn & Kelley, 1989).

Inferring memory from behaviour

There are many sorts of behaviour that suggest memory for some past event. Suppose you heard a poem some time ago. Later, you might recall the words of the poem, or recognize them when you hear them again. Alternatively, the words might sound familiar without your explicitly recognizing them. Finally, you might even be influenced by the message of the poem without having any sense of familiarity, recognition or recall.

Recall

cue information that initiates and/or aids recall

To recall information is to bring it to mind. Usually there is some *cue* that initiates and/or aids the recall. Examination questions, such as 'Contrast Piaget's developmental stages with those of Erikson', contain content cues that direct recall to information relevant to the examiner's aims. Questions such as 'What did you do on Friday night?' contain time cues. Cues such as these are very general and do not provide a great deal of information. Recall in response to these sorts of non-specific cues is generally termed *free recall*.

free recall recall in response to non-specific cues

Some cues may also be more informative and direct us to more specific events or information. Short answer examination

Figure 11.1

Memory plays a role when students remember information from a lecture and also when they do not 'remember' but are still able to use the information without bringing it knowingly to mind.

questions, such as 'What ages are associated with Piaget's concrete operational stage?', target a specific response by providing more information in the cue. A question like 'Where did you go on Friday night after you left the pub?' differs from its counterpart above by providing more information in an effort to extract some specific material. As cues become more directive, the recall is termed *cued recall*. Many factors influence the effectiveness of cues; one such factor is the amount of targeted information. The *cue overload principle* (Mueller & Watkins, 1977) states that as more information is tied to each cue a smaller proportion of that information will be recalled.

cued recall recall in response to directive cues

cue overload principle as more information is tied to each cue, a smaller proportion of that information will be recalled

Recognition

Our ability to identify some past event or information when it is presented again is termed recognition. In examinations, true–false, matching and multiple-choice questions typically target the student's ability to recognize information (e.g. 'Traits are relatively stable personality characteristics – true or false?'). In real life, questions like 'Did you go to see a film after you left the pub?' suggest some event or information and ask the rememberer whether it matches the past.

Familiarity

Effects of memory can be observed without the ability to bring to mind (that is, recall or recognize) a past event or information. Feelings of familiarity are often based on memory.

You have probably encountered someone who seemed familiar although you were unable to recognize them; often this familiarity is due to a past encounter with that person. One of the reasons for advertising is to make particular products more familiar to you, because people tend to prefer familiar things to more unfamiliar ones (Zajonc, 1968). Hence the old adage, 'All publicity is good publicity.'

Unconscious influence

Even in the absence of recall, recognition or feelings of familiarity, memory may still be detectable. If information has been previously encountered, subsequent encounters with the same information may be different due to that encounter, even in the absence of any overt signs of memory.

Unconscious effects of memory can be problematic because they may lend credibility. When people were asked whether they believed assertions such as 'The largest dam in the world is in Pakistan', they were more likely to believe these assertions if they had been encountered in a previous memory experiment, even if they could not remember these assertions in any other way (Arkes, Hackett & Boehm, 1989; Hasher, Goldstein & Toppino, 1977). Perhaps these unconscious effects of memory are the key to the effectiveness of propaganda.

Priming describes the (often unconscious) effects of a past event. It can be measured by comparing behaviour following some event with behaviour that arises if that event did not occur. In the above example, belief in those assertions may be primed by having encountered them. If two groups of people are compared – some who encountered an assertion and some who did not – the difference in their belief is a measure of the priming from the earlier encounter.

priming the effect of a previous encounter with a stimulus

Here is another example of priming. Consider the word fragment 'c _ _ p u t _ r'. A psychologist might measure how long it takes people to solve or complete the fragment to make a real English word (i.e. to say 'computer') and compare the time required by people who have recently encountered the word or idea with the time required by people who have not. Even when people have encountered 'computer' (or recently used a computer) but do not remember the experience, they can generally solve the word fragment more quickly than people without the experience. The difference in the time needed to respond is an example of priming – one type of evidence for memory (i.e. some lingering effect) of the previous experience.

Not as simple as it seems

We might consider the behaviours from which memory is inferred as existing along a continuum:

free recall . . . cued recall . . . recognition . . . feeling of familiarity . . . unconscious behavioural influence

This view suggests that differences among these manifestations of memory are due to the memories having different strengths or different availability. It would follow that where memory is strong and available, free recall is possible, along with all of the other demonstrations of memory. As memory weakens or is otherwise less available, free recall would not occur but memory might still be observable at 'lower' points (i.e. recognition, familiarity, unconscious influence).

This approach is appealing in its simplicity, but there are potential difficulties with a simple continuum. The ability to recall information does not always mean that the information will be correctly recognized (Tulving & Thomson, 1973). Also, some variables have the opposite effect on recognition and recall performance, such as word frequency. Frequently used words, such as 'table', are better recalled than lower frequency words like 'anchor', but strangely enough, the lower frequency ones are better recognized (Shepard, 1967).

Similarly, information that has been intentionally learned is generally better recalled than information that was acquired incidentally, but information that is learned unintentionally is sometimes better recognized (Eagle & Leiter, 1964). Some research suggests that a distinction between intentional and unintentional effects of memory is fundamental (e.g. Jacoby, 1991; Wegner, 1994).

The important point here is that different outcomes may be obtained when memory is inferred from different behaviours. There is no single, straightforward measure of memory, which therefore suggests that the effects of memory are not the result of a single straightforward system or process.

Constructing the past

A memory is not a copy of the world, like a video recording. It is more helpful to think of memory as an influence of the world on the individual.

A constructivist approach describes memory as the combined influences of the world and the person's own ideas and expectations. (For some classic constructivist approaches to memory, see Bartlett, 1932/1995; Bransford, 1979; Neisser, 1967, 1976.)

When two people see the same film, their reported memories of the film will be similar, but there will often be notable differences as well. Why might their reports be different? The experience of each person while they are watching the film will be somewhat different because they are different people, drawing upon different pasts with different values and goals. They might have been seated next to one another, but in some senses they actually saw (or experienced) different films.

In this way the past event as it occurred was constructed by the person who experienced it. This construction was greatly influenced by the external event (the film screening), but it was also a product of the person. The thoughts, feelings, expectations, mood, health, past experience and other characteristics of the person play a large role in how the event is experienced.

Matters are further complicated when we consider the act of remembering. Try to recall a film or television programme that you have seen recently. Some parts of the film come readily to mind; other parts you may sense yourself constructing based on the parts that you remember and what you know or believe must have happened to connect them. One of the trickiest things about remembering is that people are so good at this sort of construction that they are often unaware that it has happened. The 'constructed' memory often seems as real as the 'recollected' memory (see Neisser, 1981).

Neisser (1967) has likened remembering to the task of a paleontologist who constructs a dinosaur from an incomplete set of bones and a great deal of knowledge about dinosaurs. The past event leaves us with access to an incomplete set of bones (with occasional 'foreign' bones that are not from the past event at all). Our knowledge of the world directs our efforts to assemble those bones into something resembling the past event. The memory we construct, like the dinosaur in the natural history museum, may contain some actual elements of the past, but it is a construction that belongs to the present.

No wonder that people often find their memories to be somewhat unreliable, or that the accounts of two different people who have observed the same event may be quite different. For a summary with respect to eyewitness testimony, see Buckhout (1974).

HOW WE STUDY MEMORY

Memory can be studied in many ways, in many situations. It can be manipulated and observed in the 'real world' (e.g. Cohen, 1996; Gruneberg, Morris & Sykes, 1988; Searleman & Herrmann, 1994; Neisser, 1982). But most research has been experimental work, comparing controlled conditions in a laboratory setting.

The manipulated conditions might include any variable that is expected to influence memory, such as the familiarity of the material, the degree of similarity between study and test conditions, and the level of motivation to learn. Traditionally, researchers have studied memory for lists of words, non-words (i.e. nonsense words like 'argnop' or 'DAL'), numbers or pictures, although many other sorts of materials have been used as well, including texts, stories, poems, appointments and life events.

So most systematic investigations of memory have been experimental, conducted in a laboratory, and involving a set of to-be-remembered words or other similar materials. This description applies well to much of Ebbinghaus's (1885) work; he was the first psychologist to study memory systematically (see chapter 1).

Observation vs. inference

Remember that memory is evident to the degree that a past event influences later behaviour. So how can we know whether the later behaviour was influenced by the past event?

Try this: write down the first 15 animals that come to mind – do not read ahead – stop now and jot down a list. Next, compare your list to that on page 246. You probably had several matches. Does that mean that you correctly recalled those words? Obviously not! If you had studied the list first, could I infer that your report of an animal name was influenced by the past event? Some items you might consciously recall, some you might think of due to an unconscious influence from studying the list, and some you might think of just because they are animals – not as a result of studying the list. Would the number of matches between your list and the study list be a good measure of your memory for the list? No – the matches might occur for any of the above reasons.

The demonstration with the animal list captures an important issue in memory research. Memory is not *observed* directly – it is *inferred* from performance on a task. But performance on the task will be influenced by other factors as well as memory for the original event.

So it is clearly important to be careful about what is observed and what is inferred in memory research.

Overcoming the problem

To address this problem, memory is often studied by comparing two groups of participants or information, organized such that the 'past event' occurs for one group but not for the other. Because the only known difference between the groups is the presence or absence of the event, differences observed at the later time are assumed to reflect memory for that event. It is therefore essential to determine that there are no other differences between the groups.

The sleep learning experiment

Suppose you played tapes of information to yourself in your sleep. Would you remember the information later? (For a review of 'sleep learning', see Druckman & Bjork, 1994.) To answer the question, you might present some information to people while they sleep, wake them up, and then observe whether their subsequent behaviour reflects any memory for that information.

Wood, Bootzin, Kihlstrom and Schacter (1992) did just this. While people slept, the researchers read out pairs of category names and member names (e.g. 'a metal: gold'), repeating each pair several times. After ten minutes, the sleepers were awakened and asked to list members of named categories – such as metals – as they came to mind. The assumption was that if participants had any memory for having 'a metal: gold' read to them while they slept, then they would be more likely to include gold in their list of metals.

Comparison groups

But it clearly is not enough to observe how often 'gold' appeared in the lists. Many people, when asked to think of metals, would include gold, even without having it read to them while they slept. Researchers can overcome this type of problem by examining the difference between the performance of a comparison group or condition and an experimental group or condition (see chapter 2). So Wood et al. (1992) made two comparisons.

One comparison was between groups. Some participants were awake while the words were read to them, and some were asleep. Because people were randomly assigned to the groups, comparing how often the target words appeared in each of the groups showed whether people were more influenced by presentations while they were awake or by presentations while they were asleep. In figure 11.2, the pale bars show how often the presented words were reported. People who were awake during the presentations were more than twice as likely to report the target words as people who slept. This comparison shows that learning while awake is better than learning while asleep, but it does not rule out the possibility that the sleepers' performance was influenced by the presentations.

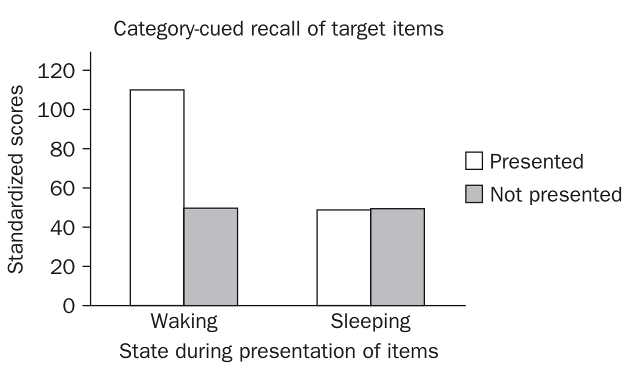

Figure 11.2

Learning while awake vs. learning while asleep: production of target items following waking and sleeping presentations. Scores were standardized on a list-by-list basis to have a mean of 50 and a standard deviation of 10. Source: Wood et al. (1992).

So the other comparison involved repeated measures (see chapter 2). Multiple observations were made for each participant and then compared. There were actually two different lists of words – one included 'a metal: gold' and the other included 'a flower: pansy'. Each participant was read only one of the lists, but all participants were tested on both categories. This allowed the experimenters to measure how often people produced words that had been read to them compared to words that had not been read to them.

The pair of bars furthest to the right in figure 11.2 shows the results for the sleepers. There was no real difference between individuals' subsequent reports of key words when the words had been read to them and when the words had not been read to them. The pair of bars furthest to the left provides the same comparison for people who were awake during the word presentations. It is pretty clear that if people were awake during word presentation, then the presentations of the lists had a big effect on subsequent memory for those key words.

MEMORY MODELS

KINDS OF REMEMBERING

Psychologists have applied a number of techniques in their efforts to understand memory. One approach has been to subdivide the vast field of memory into areas that seem to function differently from one another.

Cast your mind back to the last time you arrived home. How does that memory differ from remembering how to spell 'table', or that there are 11 players in a soccer team, or remembering how to ride a bicycle?

Our intuition would suggest that there are different kinds of remembering. But what is the evidence?

Episodic and semantic memory

One distinction made by psychologists is between episodic and semantic memory (Tulving, 1983). *Episodic memory* can be defined as memory for the personally experienced events of your life. Such memories naturally tend to retain details of the time and situation in which they were acquired. *Semantic memory*, by contrast,

episodic memory memory for personally experienced events

semantic memory abstract knowledge that is retained irrespective of the circumstances under which it was acquired (e.g. 'the world's largest ocean is the Pacific') is knowledge that is retained irrespective of the circumstances under which it was acquired.

For example, your memory of eating breakfast this morning will be an episodic one involving when, where and what you ate. On the other hand, remembering the meaning of the term 'breakfast' involves semantic memory. You can describe what 'breakfast' means but you probably have no recollection of when and how you learned the concept.

Autobiographical memory – the recall of events from our earlier life – has become a particular aspect of episodic memory that has attracted considerable interest in recent years (Cohen, 1996; Conway, 1996).

autobiographical memory the recall of events from our earlier life – a type of episodic memory

Declarative and procedural knowledge

Another sub-division of memory is between declarative and procedural knowledge (Anderson, 1976; 1995). Declarative knowledge is explicit knowledge that people are consciously aware of and can report. For example, you can probably remember eating breakfast this morning. Ryle (1949) described this type of memory as 'Knowing That'.

Procedural knowledge is a knowledge of how to do things, such as riding a bicycle or typing. Ryle referred to it as 'Knowing How'. The skills of typing, driving and so forth may be well learned and highly developed, but it is generally not easy to describe in detail how to carry them out. So an accomplished typist might find it difficult to identify each finger movement required to type this sentence, while being quite capable of typing it quickly and correctly.

Explicit and implicit memory

Another common distinction is between explicit and implicit memory. *Explicit memory* involves conscious awareness of the original information or the situation in which the learning occurred, and recollection of the original information or experience that is subsequently recalled. As these experiences involve a recollective experience, Baddeley (1997), among others, prefers to refer to 'recollective', rather than explicit, memory.

explicit memory memory with conscious awareness of the original information or the situation in which the learning occurred

Implicit memory refers to an influence on behaviour, feelings or thoughts as a result of prior experience, but without conscious recollection of the original events. For example, if you pass the fish counter in a supermarket, you might later think of having fish for dinner without being aware that 'fish' had been primed by the supermarket experience. Baddeley (1997) argues that, rather than a single implicit memory system, there is probably an array of learning mechanisms that are similar in that they influence subsequent behaviour but they do not generate recollective memories.

implicit memory influence on behaviour, affect or thought as a result of prior experience but without conscious recollection of the original events

Demonstrating the distinction

Distinctions between implicit and explicit memory are sometimes demonstrated by studies that measure priming. One task used in many priming studies is completion of word fragments (described previously for the word 'computer'). Solutions are generally faster or more certain for recently encountered words than for new ones, even when the words are not consciously recognized.

One source of evidence for the implicit/explicit distinction comes from studies involving patients with amnesia. Their amnesia means that they cannot consciously recognize words or pictures that have been previously presented, but they are nevertheless better at completing the corresponding word fragments later on (Warrington & Weiskrantz, 1968). Tulving, Schacter and Stark (1982) found a similar difference between priming and recognition test results for healthy participants not suffering from amnesia. The effect of studying a list of words on later recognition of those words declined considerably over a seven-day period, but there was no similar decline in the effects of priming of the presented words. These studies suggest that there is a fundamental difference in the functional nature of memory, depending upon whether the test requires conscious awareness of the previous event.

Jacoby (1983) provided further evidence for this view. As in the previous studies, there were two types of test: recognition (involving conscious remembering) and unconscious remembering (in this case tested via perceptual identification, i.e. identifying a word that appeared in a brief flash). Jacoby also manipulated how the words were studied. Each target word was shown with no context (e.g. 'woman'), or shown with its opposite as a context (e.g. 'man – woman'), or generated by the participant when shown its opposite (e.g. 'man' shown and 'woman' generated by the participant).

Subsequently, the explicit memory test involved showing a mixture of target words and new words to participants and asking them to identify which words they had studied ('Studied' words included both read and generated words, as described above). The implicit memory test was a perceptual identification test: a mixture of targets and new words were shown very briefly (40 ms) one at a time, and the participants attempted to identify the word.

Figure 11.3 shows the different influences of the study condition on the implicit memory measure of identification and the explicit memory task of recognition. Explicit recognition improved from the 'no context' condition to the 'generate' condition, but the reverse was the case for the implicit perceptual identification task. Because the pattern of results is reversed for the two tests, it suggests that the underlying processes (i.e.

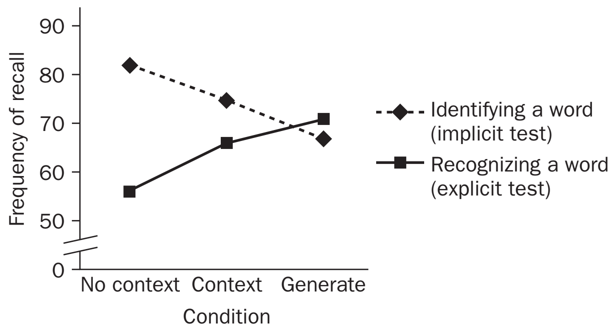

Figure 11.3

Ability to recognize a word (explicit test) vs. ability to identify it (implicit test) as a function of how the word was studied. Source: Jacoby (1983).

implicit and explicit memories) are distinct and involve possibly independent memory mechanisms.

The nature of the task

The implicit/explicit memory distinction is often tangled up (and therefore potentially confused) with two different types of task. Some tasks require people to think about meanings and concepts; these are called concept-driven tasks. Others require people to focus on the materials in front of them; these are called data-driven tasks (Roediger, 1990).

For example, if you are asked to remember words from a list that you studied, you would be explicitly recalling words and you would be likely to recall the meanings of the words as well. On the other hand, if your task was to complete word fragments, without reference to the studied list, then the influence of the study session would be implicit rather than explicit, and you would be working with the visual patterns of letters, but less so (if at all) with the meanings.

It is challenging to separate the nature of the task (i.e. concept- or data-driven) and the nature of the memory being tested (i.e. explicit or implicit) (see Roediger & Blaxton, 1987). Roediger, Buckner and McDermott (1999) review the debate between explanations based upon memory systems and memory processes.

The experience of remembering (or knowing)

Related to the explicit/implicit memory distinction is the experience that accompanies performance on the memory task. A participant may remember having seen the item under test in a recognition experiment at the original learning trial, or they may simply 'know' that the word was in the original list without specifically recalling it.

This 'remember/know' distinction was first used by Tulving (1985). He required each response in the memory test to be judged as being accompanied by an experience of remembering having studied the item, or, alternatively, of knowing that the item had been presented without specifically remembering the event. Gardiner and associates have since carried out extensive investigations of 'remember/know' judgements under a range of different conditions (reviewed by Gardiner & Java, 1993).

A number of conditions have been shown to influence 'remember' and 'know' judgements differently. For example, semantic processing (where the meaning of the items is foremost) leads to more 'remember' responses than does acoustic processing (which emphasizes the sound of the words studied). In contrast, 'know' responses do not differ between the semantic and acoustic conditions.

The information-processing metaphor

In the 1960s subdivisions of memory based upon information-processing models became popular. Following postwar developments in information technology, there had been a substantial growth in understanding the requirements of information storage during computer processing.

A three-stage model of memory processing developed, reaching its fullest elaboration in the version proposed by Atkinson and Shiffrin (1968). In these stage models, information was considered to be first held very briefly in sensory memories before a selection of this information was transferred to a *short-term store*. From here, a yet smaller amount made its way into a *long-term memory store*.

short-term store hypothetical memory store holding information for a few seconds

long-term memory store holds information relatively permanently

Sensory memories

Evidence for *sensory memory* stores came from experiments such as Sperling's (1960). He presented displays of 12 letters very briefly (e.g. 50 ms) to participants. Although they could report only about four letters, Sperling suspected that they might actually be able to remember more letters, but they could not hold them in mind long enough to report them.

sensory memory hypothetical large capacity memory store holding incoming sensory information for a brief period of time

To test this hypothesis, Sperling briefly presented the letters as a matrix containing three rows, and then sounded a tone (see figure 11.4). Participants had been instructed to report only part of the array – which part depended on the pitch of the tone. Using this *partial report procedure*, Sperling found that people could recall about three letters from any row of four, which meant that they

partial report procedure technique for inferring the capacity of a memory store, even when the memories do not last long enough to inform a complete report

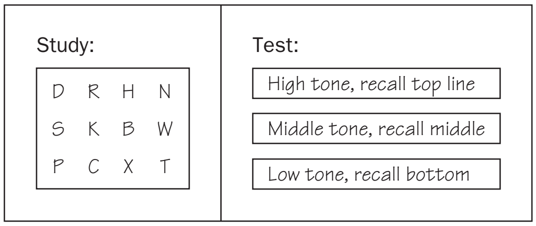

Figure 11.4

Sperling's (1960) partial report technique.

could actually potentially recall (for just a very brief period) about nine out of the twelve letters.

Psychologists inferred from research such as this that there is a sensory memory store which holds a large amount of incoming perceptual information very briefly while selected elements are processed. This sensory memory for visual information was termed *iconic memory* by Neisser (1967). Sensory memory for auditory information was referred to as *echoic memory*. Sensory memories are generally characterized as being rich in content, but very brief in duration.

iconic memory visual sensory memory

echoic memory auditory sensory memory

Short- and long-term memories

Beyond the sensory memories, the information-processing models hypothesized one or more short-term stores that held information for a few seconds. The verbal short-term store has received the most research attention, its existence being inferred in part from the *recency effect* in free recall.

recency effect the better recall of the last few items of information encountered

For example, Postman and Phillips (1965) asked their participants to free recall lists of 10, 20 or 30 words. With immediate recall, the participants tended to be much better at recalling the last few words that had been presented than words from the middle of the list (see the top part of figure 11.5.) But this recency effect disappeared if testing was delayed by as little as 15 seconds, so long as the delay involved verbal activity by the participant (see the middle and bottom parts of figure 11.5.) The interpretation of the recency effect was that the last few items were being retrieved from a short-term store of rather limited capacity.

The short-term store was believed to retain information primarily in an acoustic or phonological form (Baddeley, 1966) – a view that received additional support from the errors that appear during short-term retention, even when the material to be retained is presented visually. Conrad and Hull (1964), for example, showed that visually presented sequences of letters that are similar in sound (e.g. P, D, B, V, C, T) were harder to recall correctly than were sequences of dissimilar-sounding letters (e.g. W, K, L, Y, R, Z).

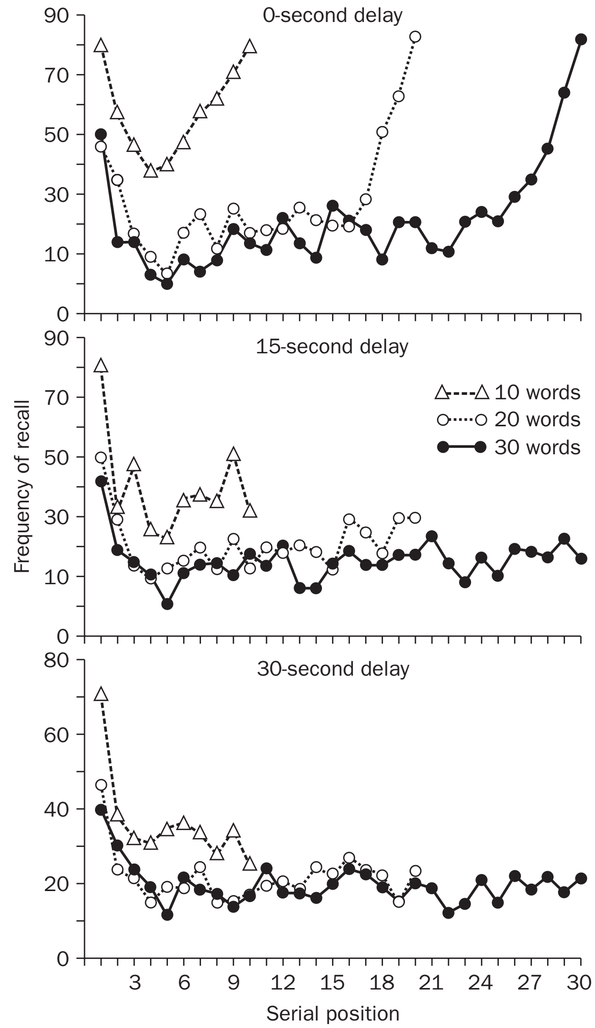

Figure 11.5

Recency effect (with no delay) and removal of recency effect by introducing a delay between presentation and test. The top panel shows high levels of recall for items near the end of the lists (recency effect) when there is no delay between presentation and test. The middle and bottom panels show that recall for items near the end of the list suffers far more than for other items in the list as a result of introducing even a very short (15-second) delay. Source: Postman and Phillips (1965).

On the other hand, long-term memory was believed to be stored primarily in terms of the meaning of the information. So, when asked to remember meaningful sentences, people usually cannot reproduce the exact wording, but they can generally report the meaning of what has been encountered (e.g. Sachs, 1967).

Developing the models

While models like Atkinson and Shiffrin's (1968) are useful ways to simplify and represent aspects of complex systems, this very complexity requires ongoing adjustment to enable these models to account for additional observations.

For example, the information-processing model made two assumptions:

1. that information could only reach long-term memory by passing through the short-term store; and
2. that rehearsing the information in the short-term store would both retain it in this store, and increase its chance of being selected for transfer to the long-term store.

The first of these assumptions was challenged by the identification of patients who had grossly impaired short-term memory spans and therefore (in terms of the model) severely damaged short-term memory stores, but who appeared to have no impairment in their long-term learning ability (Shallice & Warrington, 1970).

The second assumption was called into question by studies where participants rehearsed the last few words of free recall lists for a longer time without showing improvement in the long-term recall of those words (Craik & Watkins, 1973). Under some circumstances, it became clear that encountering the same information on many occasions (which may also be assumed to lead to increased rehearsal) was not sufficient to lead to its retention. For example, people do not remember the details on the faces of the coins that they handle daily (Morris, 1988; Nickerson & Adams, 1979), as you discovered when you tried to sketch a penny at the beginning of the chapter.

Other evidence that previously formed the basis for distinguishing between short-term and long-term memory stores has also come into question. For example, the recency effect in free recall had been attributed to the operation of a short-term store because it disappeared when the last few seconds before recall were filled with a task such as backward counting. But when recall was studied under different conditions, recency effects reappeared even without a contribution from short-term memory. When participants studied words and counted backwards after each word in the list, the last few items were better recalled than the middle of the list (as illustrated at the top of figure 11.5). This pattern was at odds with the model, because the short-term store should have been 'filled' with counting, and so no recency effect should have been observed (e.g. Baddeley & Hitch, 1977; Tzeng, 1973).

Semantic encoding was also demonstrated in short-term learning under suitable conditions (Baddeley & Levy, 1971), showing that phonetic encoding was not the only form of coding relevant for the short-term store.

Two major responses followed recognition of the problems with the Atkinson and Shiffrin (1968) information-processing model. One approach, especially associated with Baddeley et al. (e.g. Baddeley, 1986), was to enhance the short-term memory model in the light of its known limitations, along with more consideration of the functions that short-term remembering plays in cognition. This change in perspective led to Baddeley's (1986, 1997, 2001) working memory model.

The other response was to question the emphasis on memory stores and their capacity limitations, and to focus instead on an alternative approach based on the nature of the processing that takes place, and its consequences for remembering.

Baddeley's working memory model

Baddeley's (1986, 1997) model of working memory involves three main components: a *central executive*, and two so-called 'slave' systems – the *phonological loop* and the *visuo-spatial sketch pad*. To these Baddeley (2001) has added an *episodic buffer*.

The central executive controls attention and coordinates the slave systems; the phonological loop contains a phonological store and an articulatory control process and is responsible for inner speech; the visuo-spatial sketch pad is responsible for setting up and manipulating mental images; the episodic buffer integrates and manipulates material in working memory.

central executive the component of Baddeley's working memory model that controls attention and coordinates the slave systems

phonological loop the part of Baddeley's working memory model that contains a phonological store and an articulatory control process – responsible for 'inner speech'

visuo-spatial sketch pad the part of Baddeley's working memory model that is responsible for setting up and manipulating mental images

episodic buffer the component in Baddeley's working memory model that integrates and manipulates material in working memory

The phonological loop

Much research has been concentrated on the phonological loop. By using a technique known as *articulatory suppression*, in which research participants repeat aloud (or silently) a simple sound or word, such as 'la la la' or 'the the the', the phonological loop can be prevented temporarily from retaining any further information. So contrasting performance with and without articulatory suppression demonstrates the contribution of the phonological loop.

articulatory suppression a research technique in which participants repeat aloud a simple sound or word, preventing the phonological loop from retaining any further information

Like any loop, the phonological loop has a finite length. That length could be specified as a number of items or as a length of time. Baddeley, Thomson and Buchanan (1975) investigated this question. They showed that *memory span* – the number of words that you can hear and then repeat back without error – is a function of the length of time that it takes to say the words. A word list like 'mumps, stoat, Greece, Maine, zinc' is much easier to remember in a short-term memory test than 'tuberculosis, hippopotamus, Yugoslavia, Louisiana, titanium', even though the two lists are matched in terms of the number of words and the meaning. This word length effect is eliminated if the participants have to carry out articulatory suppression while they study the list.

memory span the number of words that you can hear and then repeat back without error

Another example comes from the varying speed with which the digits 1 to 10 can be pronounced in different languages. The size of the memory span for people who speak each language is highly correlated with the speed with which the digits can be spoken in that language (Naveh-Benjamin & Ayres, 1986). These and other observations demonstrate that the phonological loop must be time-limited.

The central executive and the sketch pad

More recently, Baddeley and his associates have turned to studying the central executive. Their technique is to ask people to perform two tasks at the same time. One of the tasks (the first task) is designed to keep the central executive busy, while the second task is being evaluated for whether the central executive is involved in its performance. When performance on the second task suffers due to the presence of the first task, they conclude that the central executive is involved in performing the second task.

One task used to engage the central executive is the generation of random letter sequences. Participants generate letter sequences taking care to avoid sequences of letters that fall into meaningful orders, such as (T, V), (B, B, C) or (U, S, A). Participants must attend carefully to their letter choice, and this monitoring occupies the central executive.

Robbins et al. (1996) showed that the memory of expert chess players for positions taken from actual chess games was impaired by the letter generation task but not by articulatory suppression, indicating that the central executive was involved in remembering the chess positions. These researchers also found that another task which is believed to interfere with the visuo-spatial sketch pad also reduced chess performance, reflecting the contribution of spatial short-term memory in the reproduction of the chess layouts.

The episodic buffer

Information that is retrieved from long-term memory often needs to be integrated to be appropriate for the current demands upon working memory. This is an important function of the episodic buffer proposed by Baddeley (2001). Baddeley gives the example of imagining an elephant who plays ice-hockey. We can easily go beyond the information about elephants and ice-hockey our long-term memory supplies us to imagine how the elephant holds the hockey stick and what position it might play. The episodic buffer allows us to go beyond what already exists in long-term memory, to combine it in different ways, and to use it to create novel situations on which future action can be based.

Levels of processing

Another alternative to the continuing development of structural models has been to emphasize the importance of processing in memory, rather than structure and capacity.

Craik and Lockhart (1972; Craik, 2002) argued that how well we remember depends on how we process information. They described different *levels of processing*, from 'superficial' levels that deal only with the physical properties of what is to be remembered, through 'deeper' processes involving phonological properties, down to yet deeper processes that involve semantic processing of the material (i.e. perhaps involving elaboration of the material).

levels of processing – the theory that there are superficial, intermediate and deeper levels of processing new information that will influence what can later be remembered

So, for example, if we see the word 'SHEEP', we might simply process it shallowly by noting that it is written in upper case. On the other hand, we might process it phonologically by registering that its sound rhymes with 'leap' and 'deep'. Alternatively, we could think about the meaning of the word: 'sheep' refers to domesticated, woolly, grazing animals. Further semantic processing – elaboration based on the meaning of the word – is deeper processing, and should lead to better memory (for example, we might think about the grazing of sheep, the uses of sheep – for example, in providing food and material for clothing – and the large number of sheep in some parts of the world, such as Australia and New Zealand).

Demonstrating the power of this approach, Craik and Tulving (1975) showed that the probability of the same word being recognized in a memory experiment varies from 20 per cent to 70 per cent, depending on the type of processing that is carried out on the word (see figure 11.6). When the initial processing involves only decisions about the case in which the word is printed, correct recognition occurs at the 20 per cent level. Performance is better following the rhyming (i.e. phonological) decisions, and far better (almost 70 per cent correct recognition) when processing involves decisions about whether the word fits meaningfully into a given sentence.

Although many studies support the model, the details of the original 'levels of processing' model have been criticized (e.g. Baddeley, 1978). For example, it has been argued that a level of processing cannot be identified independently of the memory performance that it produces (in other words, it has been

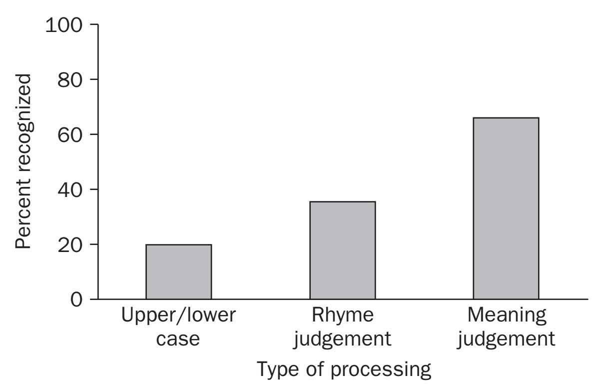

Figure 11.6

Percentage of words correctly recognized as a function of processing type (i.e. level). Performance is based on both studied items and distractors. Source: Craik and Tulving (1975).

suggested that the definition of what constitutes 'deep' and 'shallow' processing is circular). More recently, though, Craik (2002) has pointed to physiological and neurological methods that may provide an independent measure of depth.

Thoughtful discussion about the viability of the model continues. Wherever it leads, it is clear that a 'levels of processing' approach draws attention to important memory-related issues including the type of processing, elaboration of materials, and the appropriateness of this processing (in terms of 'transfer' to the later task). A key message from this research is that what we remember depends on what we ourselves do when we encounter a thing or an event, as well as the properties of the thing or event itself.

The link between study and test

The encoding specificity principle

encoding specificity principle states that what is remembered later depends on the similarity of the retrieval situation to the original encoding conditions

Tulving (1983) developed the *encoding specificity principle*, which emphasizes the relationship between what occurs at study time (encoding) and what occurs at test time (retrieval).

What is encoded in any particular situation is selective – it is determined by the demands on the individual at study time. According to the encoding specificity principle, what will be remembered later depends on the similarity between the memory test conditions and the original study conditions.

Pioneer

Endel Tulving (1927–) has been a dominant figure in research on memory for several generations and a pivotal figure in the late twentieth century. His work on subjective organization demonstrated that participants in memory studies are not passive but impose their own organization and expectations upon the material they study. He drew attention to a distinction, originally made by Plato, between the availability of items in memory and their accessibility. Tulving is even better known for his work on the relationship between what is encoded and what can be retrieved. He developed the encoding specificity principle and collaborated with Craik in exploring the 'levels of processing' framework. He was also the first psychologist to suggest that episodic and semantic memories were two separate memory systems. More recently, with Schacter, he has been involved in a considerable body of research and theorizing on the distinction between implicit and explicit memories and in research on the neuropsychological correlates of memory.

An experiment by Barclay et al. (1974) nicely illustrates encoding specificity. They required participants to study a series of sentences with key words embedded in the sentences. So, for example, the word 'PIANO' was presented in one of two sentences: 'The man tuned the PIANO' or 'The man lifted the PIANO.' Recall of the sentences was cued by phrases that were either appropriate or inappropriate to the particular attributes of the named object (the piano).

Cued with the phrase 'something melodious', participants who had received the sentence about tuning the piano remembered 'PIANO'. Participants who had studied the sentence about the piano being lifted were less likely to recall 'PIANO' after the 'something melodious' cue, because the melodious aspect of the piano had not been emphasized in their sentence. Conversely, participants who had studied the sentence about lifting the piano were more effectively cued at test by the phrase 'something heavy' rather than the cue 'something melodious'.

This experiment demonstrates two important aspects of encoding specificity:

1. Only those aspects of our experience that are specifically activated by the study situation are certain to be encoded.
2. For information to be optimally recalled, test cues need to target the particular aspects of the information that were originally encoded. In other words, remembering depends on the match between what is encoded and what is cued.

Transfer appropriate processing

To achieve the best recall, the type of processing involved when studying needs to be appropriately matched to the type of processing that will be required for the test.

transfer appropriate processing for the best recall, the type of memory encoding needs to be appropriately matched to the type of cueing information that will be available at recall

Morris, Bransford and Franks (1977) demonstrated the effect of *transfer appropriate processing* in an extension of the Craik and Tulving (1975) 'levels of processing' experiments. In the original Craik and Tulving studies, participants were encouraged during encoding to focus on the physical, phonological (e.g. rhyming) or semantic aspects of the to-be-remembered word. Under typical testing conditions, semantic processing during encoding led to the best level of recall during testing. But in the Morris et al. study, a condition was added in the test phase: participants had to identify words that rhymed with the words presented earlier during encoding. In this new condition there was a closer match between the task carried out in the learning phase (identifying words that rhymed) and the task carried out in the test phase (identifying the words that rhymed with words presented in the learning phase). Recall for rhyming words was best when rhyming had been the focus of the learning task.

WHAT DO WE KNOW ABOUT MEMORY?

Memory and the brain

Psychologists' study of memory has focused, appropriately, on what people do, say, feel and imagine as a result of their past experiences. But how are these activities of remembering reflected in our brain (see chapter 3)?

The study of amnesia has been important in recent years, not only as a way of discriminating between certain types of memory processes, but also in linking deficits in remembering with localized brain damage in patients who have sustained injury. In addition, the development of techniques such as functional magnetic resonance imaging (fMRI) has added significant new information by allowing us to study the parts of the brain that are active when ordinary people remember. For an excellent review of this research, see Parkin (1997).

Making generalizations about memory and the brain is difficult because remembering is a complex process, involving most other cognitive and emotional aspects of a person. So many parts of the brain will be active when someone is remembering. We cannot just remember something without also feeling and thinking, so it is very hard to isolate any neural activity that might be unique to remembering. But certain parts of the brain do seem to be important to memory in particular.

For example, damage to the hippocampus and the thalamus can prevent new episodic memories being formed (Squire, 1992). Patients with hippocampal damage can learn new skills without forming episodic memories. So the patient H.M. (see chapter 3), who had had his hippocampus surgically removed, was eventually able to solve a complicated puzzle that he attempted over many days. Yet each time he was given the puzzle, he denied having ever seen it before (Cohen & Corkin, 1981). This tells us that the hippocampus appears to play an important part in the formation of episodic memories.

The importance of meaning

Remembering names

Meaning plays a major role in determining what we can remember. Consider the case of remembering (or rather forgetting) names. People who feel they have a bad memory commonly complain that they find names especially difficult to remember. In fact, people are generally poor at dealing with a new name. When introduced to a new person, our minds are usually occupied and so we fail to attend to their name. Then we most likely do not use or try to think of the name until much later, by which time memory often fails. But there is more to the problem of remembering names than merely not paying attention and not using the names until much later.

Cohen and Faulkner (1986) presented participants with information about fictitious people: their names, the places they came from, their occupations and hobbies. The participants remembered all of the other attributes better than the names. Why? Not merely because names are unfamiliar words – many names are also common nouns (e.g. Potter, Baker, Weaver, Cook).

McWeeny, Young, Hay and Ellis (1987) tested people who studied the same set of words; sometimes the words were presented as names, sometimes as occupations. The same words were remembered much better when presented as occupations than as names. It is apparently easier to learn that someone is a carpenter than that they are named Mr Carpenter!

Nevertheless, names that are also real words do have an advantage over 'non-word' names. Cohen (1990) showed that meaningful words presented as names (e.g. Baker) are better remembered than meaningless words presented as occupations (e.g. ryman). Even so, names are often treated as being meaningless – think for a second how it sometimes comes as a surprise when we recognize that they are also occupations (for example, the names of the former British prime ministers Thatcher and Major). We know that attending to the meanings of names can improve memory for them, especially when combined with practice in recalling them (Morris & Fritz, 2002, 2003).

One aspect of what makes a word meaningful is the associations that it has with other terms (Noble, 1952). Words that trigger more associated words (e.g. 'kitchen') certainly seem more meaningful than unusual words (e.g. 'rostrum') and these, in turn, seem more meaningful than non-words (e.g. 'gojey'). The lack of associations to some names may be one of the main reasons they are hard to learn. Cohen and Burke (1993) point out that many names lack semantic associations, while occupations have many semantic associations.

Nonsense and droodles

Meaning has a major influence on memory. Ebbinghaus (1964/1885) recognized that the study of material which already had

> **Pioneer**
>
> **Hermann Ebbinghaus** (1850–1909), a German philosopher, read Fechner's work on the study of sensation and perception in the late 1870s and decided to adapt these methods to the study of memory. He devised a systematic way of simplifying memory tasks so that aspects of memory could be manipulated and measured. Ebbinghaus invented syllables made up of two consonant sounds separated by a vowel (e.g. 'tir', 'kam', 'dol') in an attempt to avoid the contaminating effects of prior familiarity, and then measured the number of repetitions required to learn them. He also devised a clever way of measuring forgetting. He counted the number of repetitions required to re-learn the material and found that it usually took fewer repetitions to re-learn something than to learn it in the first place. Ebbinghaus's experimental method for the study of memory established a major field of psychology and continues to influence our understanding of memory today.

Everyday Psychology

Learning people's names

'I have problems remembering people's names!' We hear this complaint regularly. Higbee (2001) found, when questioning people about the aspects of memory they would most like to improve, that remembering people's names was by far the most popular choice. It is a problem that probably becomes even greater as we get older: Bolla, Lindgren, Bonaccorsy and Bleecker (1991) found that the memory problem most frequently reported by older people was forgetting names.

Psychological research has confirmed that names are particularly hard to remember. Cohen and Faulkner (1986) found that, after studying biographical sketches, recall of person names was poorer than recall of any other type of information from the sketches. McWeeny, Young, Hay and Ellis (1987) taught participants names and occupations in association with photographs of faces. They chose words such as Cook, Porter and Carpenter, sometimes using the words as names and sometimes as occupations. McWeeny et al. found that the words were much easier to learn when presented as occupations than when presented as names.

Why should names be difficult to learn? In everyday life, we often pay insufficient attention to a name when we are introduced to a new person. Also, we do not usually repeat the name right away or use it during the initial conversation. After half-hearing the name once, it may be some time before we try to recall it – only to find it has been forgotten.

Another problem may be that names are generally perceived as meaningless. Even so, names are better recalled than meaningless non-words (Cohen, 1990).

How can we improve our learning of names? The section on mnemonics (pp. 243–4) includes an imagery mnemonic that Morris et al. (1978) showed to be effective under laboratory conditions. Unfortunately, imagery mnemonics demand creativity and attention and can be distracting when used for the first time. Perhaps these demands explain why Morris et al. (in press) found the mnemonic to be unsuccessful when people attending a party were encouraged to use it to learn the names of those present. The mnemonic probably requires considerable practice and motivation before it can be used successfully in everyday life.

Are there memory improvement strategies to improve name learning that can be easily and successfully adopted under real-world conditions? Fortunately, the answer is yes. To improve your memory for people's names, simply test yourself. Try to recall the person's name shortly after being introduced and again after a minute or so, and again later after somewhat longer delays. In one experiment students at a party who used this method were better at remembering names days later. Under laboratory conditions, combining this technique with trying to identify meaningful associations to the name makes it even more successful (Morris & Fritz, 2003).

In classes and meetings it is common for everyone to introduce themselves during the first meeting, but the names are rarely well remembered. An alternative activity, called the 'Name Game', has proved effective in a series of experiments (Morris & Fritz, 2000; 2002; Morris, Fritz & Buck, 2004). As each person introduces themselves, they must also attempt to recall the names of the other people present. The people who introduce themselves first, and so have few names to recall, are asked to recall everyone later on. This activity is often used in real meetings and seminars, sometimes with a few test rounds in the second meeting. People who play the 'Name Game' are better at remembering their colleagues' names, even after several weeks or months.

Morris, P.E., & Fritz, C.O., 2000, 'The name game: Using retrieval practice to improve the learning of names', *Journal of Experimental Psychology: Applied*, 6, 124–9.

meaning for the learner would be influenced by that meaning. So it seemed to Ebbinghaus that if he was to discover the fundamental principles of memory, then he would need to study the learning of simple, systematically constructed materials. He created syllables by stringing together a consonant sound, a vowel sound and a consonant sound. Some of these were words or meaningful parts of words but most were simply syllables. He made lists of these syllables and learned them in order – often requiring many trials to learn them perfectly (see also chapter 1). In contrast to his experience learning poetry, learning these syllables was slow.

A demonstration of the importance of meaning for the recall of very different material was provided by Bower, Karlin and Dueck (1975). They studied memory for droodles – simple line drawings of nonsense pictures (see figure 11.7). Some participants

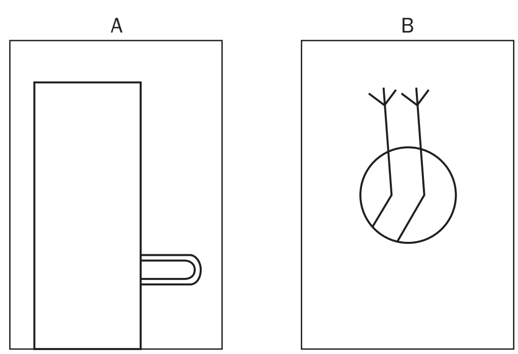

Figure 11.7

Examples of two droodles. Source: Bower, Karlin and Dueck (1975).

were given a meaning for each droodle (e.g. a midget playing a trombone in a telephone booth; an early bird who caught a very strong worm). These individuals were able to sketch the pictures from memory far better (70 per cent correct) than participants who were not given these meanings (51 per cent correct).

The effects of previous knowledge

Schemas – what we already know

Bartlett (1932) asked English participants to read and then recall a Native American folk tale, *The War of the Ghosts*, which came from a culture that was very different from their own. When they attempted to recall the story, their reports were obviously based on the original tale, but they had added, dropped and changed information to produce stories that seemed more sensible to them – what Bartlett termed an 'effort after meaning'.

schemata (schemas) knowledge structures that help us make sense of familiar situations, guiding our expectations and providing a framework within which new information is processed and organized

Bartlett proposed that we possess *schemata* (or *schemas*), which he described as active organizations of past experiences. These schemas help people to make sense of familiar situations, guiding expectations and providing a framework within which new information is processed. For example, we might possess a schema for a 'typical' day at work or at school.

People seemingly have trouble understanding things if they cannot draw upon memory, or schemas, for previously acquired knowledge. This point was nicely illustrated in a study by Bransford and Johnson (1972). They gave participants a passage to remember, which began as follows:

> The procedure is actually quite simple. First you arrange items into different groups. Of course one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step; otherwise you are pretty well set. It is important not to overdo things. That is, it is better to do too few things at once than too many. . . . (p. 722).

Recalling the passage proved difficult, even if a title was given after the passage had been read. Bransford and Johnson (1972) found that it was only when the title ('Washing Clothes') was given in advance that recall was improved. The title explained what the passage was about, cued a familiar schema and helped people to make sense of the statements. With the title provided first, the passage became meaningful and recall performance doubled. So it seems that memory aids understanding; and understanding aids memory.

It is possible to remember without understanding, though – especially with extra aids, such as having the information presented for verification. Alba, Alexander, Hasher and Caniglia (1981) demonstrated that, although recall of the 'Washing Clothes' passage was much improved when the title was known in advance, recognition of sentences from the passage was equivalent, with or without the title. Alba and colleagues concluded that the title allowed the participants to integrate the sentences into a more cohesive unit, but that it affected only the associations among the sentences, not the encoding of the sentences themselves (which is why recognition performance was apparently preserved).

The research with the 'Washing Clothes' passage illustrates how our previous knowledge helps us to remember. Bower, Clark, Lesgold and Winzenz (1969) provided another demonstration. They asked participants to learn sets of words that were presented either as a random filled hierarchical chart or in a well-organized one: see, for example, the hierarchy in figure 11.8.

Pioneer

Sir Frederick C. Bartlett (1886–1969) was one of Britain's greatest psychologists. Although he began his research using Ebbinghaus's methods and materials, he was dissatisfied with the limits of simple artificial materials and turned his attention to how people recall stories and pictures. His studies remained experimental and carefully controlled, but he began to use materials 'of the type which every normal individual deals with' (1932, p. v). Whereas Ebbinghaus tried to limit the effects of meaning and studied the effect of other variables on memory, Bartlett's emphasis was on the role of meaning and social influences upon remembering. Even today, his work is often cited and is the basis of much contemporary research.

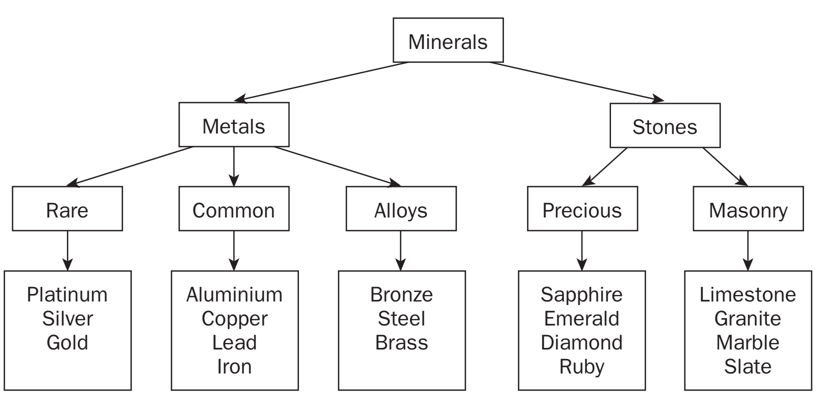

Figure 11.8

Organized hierarchical information used by Bower et al. (1969).

Research close-up 1

Hierarchical retrieval schemes in recall of categorized word lists

The research issue

The focus of research by Bower et al. (1969) was the influence of presenting words in a structured hierarchy (see figure 11.8), compared with presenting the same words in a random structure.

The first experiment was a simple comparison of free recall of hierarchical word lists presented in a blocked as opposed to a random fashion. Four word hierarchies were learned concurrently. The participants in the blocked condition were exposed to the four conceptual hierarchies organized as vertical trees, as shown in figure 11.8. For participants in the random condition, the same words were thoroughly scrambled, then assigned randomly to the nodes of four special trees.

Design and procedure

Sixteen undergraduates served as participants, eight in each of two conditions, blocked and random. In each condition, four hierarchies were presented, with an average of 28 words in each. The hierarchies were presented on large cards, with a study time calculated at 2s per word on the card. In the random condition, the same set of 112 words was used with the words randomly positioned.

After seeing the four cards, the participants recalled the words aloud in any order they preferred.

Results and implications

Table 11.1 shows the number of words presented and the level of recall on each of four trials for the blocked and random conditions. The mean recall on trial 1 was 3.5 times better in the blocked than the random condition. In the blocked condition, recall was almost perfect by trial 2. The structural organization of the blocked words had a statistically significant effect on free recall in this situation.

Table 11.1 Average words recalled over four trials.

	Trials			
Condition	*1*	*2*	*3*	*4*
Words presented	112	112	112	112
Blocked	73.0	106.1	112	112
Random	20.6	38.9	52.8	70.1

The researchers concluded that the blocking of the words had a substantial effect on recall. In four later experiments reported in this paper, they continued to investigate similar tests of memory. They explored recognition performance, and investigated associative rather than conceptually organized word hierarchies.

Bower, G.H., Clark, M.C., Lesgold, A.M., & Winzenz, D., 1969, 'Hierarchical retrieval schemes in recall of categorized word lists', *Journal of Verbal Learning and Verbal Behavior*, 8, 323–43.

Bower and his colleagues found that presenting the words in meaningful hierarchies reduced the learning time to a quarter of that required for the same words when they were randomly positioned in the hierarchy. The organization of the hierarchy apparently emphasized aspects of the words' meanings, which appeared not only to simplify the learning of the lists but also to provide a framework within which the participants could structure their recall.

How knowledge promotes remembering

Experts in any area find it easier and quicker to learn new information within their expertise than do novices. This indicates that what we learn appears to depend heavily on our existing knowledge.

For example, Morris, Tweedy and Gruneberg (1985) showed that there was a very strong relationship between how much their participants knew about soccer and the number of new soccer

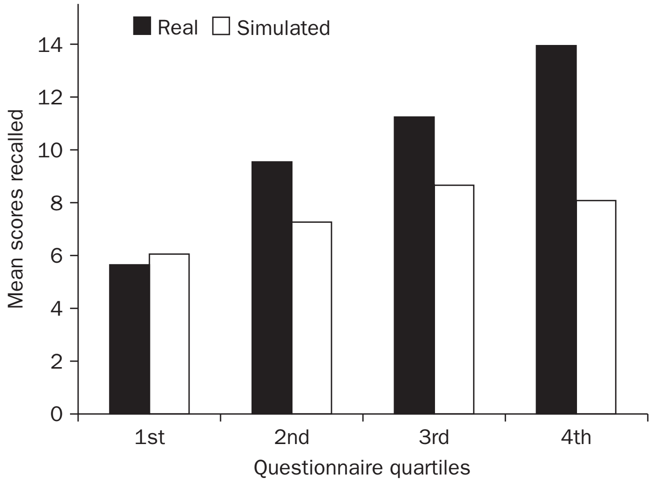

Figure 11.9

Recall of real and simulated soccer scores as a function of relative expertise, measured by a questionnaire on soccer knowledge. Recall of real soccer scores increased with expertise; for simulated soccer scores, it did not. Source: Morris, Tweedy and Gruneberg (1985).

scores they could remember after hearing them just once. Participants were read a new set of soccer scores as they were being broadcast. One set of scores were the real scores, and another set was simulated by constructing plausible pairs of teams and assigning goals with the same frequency as had occurred in an earlier week. Participants in the study were told whether the scores they heard were real or simulated.

Figure 11.9 illustrates the recall of the participants, with the first quartile (the first of four groups) knowing the least and the fourth quartile the most about soccer. Only the real scores seemed to activate the knowledge and interest of the soccer experts. For real scores (the darker bars in the figure), level of memory recall was clearly related to expertise – so more knowledgeable fans recalled more. For simulated scores (the pale bars), where the scores were highly plausible but not the genuine results, expertise had little effect on recall performance. These results illustrate the interaction of memory capacity with existing knowledge (and, presumably, also interest and motivation) in determining what is remembered.

How knowledge leads to errors

Our previous knowledge is a very valuable asset, but it can also lead to errors. Owens, Bower and Black (1979) illustrated this point well. They gave their university student participants a description of the activities performed by a character. For example, one of the sketches was about a student named Nancy. Here is the first part of that sketch:

> Nancy went to the doctor. She arrived at the office and checked in with the receptionist. She went to see the nurse who went through the usual procedures. Then Nancy stepped on the scale and the nurse recorded her weight. The doctor entered the room and examined the results. He smiled at Nancy and said, 'Well, it seems my expectations have been confirmed.' When the examination was finished, Nancy left the office. (p. 186)

Half of the participants were told in advance that Nancy was worried that she was pregnant. These participants included between two and four times as many pieces of incorrect information when tested on their recall of the sketch. For example, some of them recalled 'usual procedures' as 'pregnancy tests'. The errors were made in both recognition and recall tests.

People have many expectations about how conventional activities (going to the doctor, a lecture, a restaurant) will proceed, and these provide schemas or scripts that can both aid and mislead. Bower, Black and Turner (1979), for example, studied the influence of such scripts on subsequent recall. In another part of their study, they also gave their participants stories based on normal expectations, but including variations from the norm. So, for example, a story about eating in a restaurant might refer to paying the bill at the beginning. When recalling these stories, participants tended to reorder them back to their schematic form or script. Other common errors involved including actions that would normally be expected in that context, but which had not been mentioned in the original story, such as looking at the menu.

In general, the findings of these and similar studies indicate that people tend to remember what is consistent with their schemas or scripts and to filter out what is inconsistent.

REAL VS. IMAGINED MEMORIES

Even when we believe that we are 'playing back' some previous event or information in our mind, as if it were a videotape, we are actually constructing a memory from bits and pieces that we remember, along with general knowledge about how these bits should be assembled.

This strategy is usually very adaptive, minimizing our need to remember new things that are very similar to things we already know. But sometimes there can be a blurring between what actually happened and what has been imagined or suggested.

Reality monitoring

The issue of reality monitoring – identifying which memories are of real events and which are of dreams or other imaginary sources – has been addressed by Johnson and Raye (1981). These researchers maintain that the qualitative differences between memories are important for distinguishing *external memories* from internally generated ones. They argue that external memories have stronger sensory attributes, are more detailed and complex and are set in a coherent context of time and place. By contrast, they argue that internally generated memories have more traces of the reasoning and imagining that generated them.

external memories memories of events that really occurred

Although Johnson (1988) found support for these differences, applying them as tests can lead to accepting memories as real, even when they are not. Morris (1992), for example, asked participants to recall details from a videotape and to report both their confidence and the presence or absence of clear mental imagery and detail. Although clear images and details were found to occur more often with correct reports, their presence led people to be overly confident: incorrect details accompanied by mental images were reported with greater confidence than correct details that lacked these images. So there does not seem to be any sure way of distinguishing between 'real' and 'imagined' memories.

Related to the concept of reality monitoring is *source monitoring* – being able to successfully attribute the origin of our memories (e.g. being able to state that we heard a particular piece of information from a friend rather than hearing it on the radio news broadcast). Errors in attributing memories can have important consequences – for example, during eyewitness testimony (Mitchell & Johnson, 2000).

Research close-up 2

When might a witness be misled?

The research issue

Eyewitnesses to an event can be misled by false information or suggestions they encounter after the event. Elizabeth Loftus and her colleagues (Loftus & Loftus, 1980; Loftus, Miller & Burns, 1978) identified this *misinformation effect*, and, along with many other psychologists, they have continued to explore when and why it occurs.

Saunders and MacLeod (2002) suggested that misinformation influences memory only when the witness is unable to consciously recall the original, correct information. They used a phenomenon known as *retrieval-induced forgetting* (Anderson, Bjork & Bjork, 1994) to test their hypothesis. Retrieval-induced forgetting occurs when some parts of a set of information are practised (i.e. repeatedly tested and recalled), then the parts that are not practised become temporarily more difficult to recall. Saunders and MacLeod predicted that people would adopt misinformation for forgotten parts, but not for information they remember, so they used retrieval-induced forgetting to make people remember or temporarily forget parts of a story.

retrieval-induced forgetting when some parts of a set of information are practised (i.e. repeatedly tested and retrieved), the parts that are not practised become temporarily more difficult to recall

Design and procedure

Participants were 100 undergraduate volunteers. Each participant studied short stories containing information about two burglaries and later received misinformation about one aspect of one burglary. Participants in the key experimental conditions practised (i.e. repeatedly tested and recalled) half of the information about one burglary. Misinformation was given to conflict with one aspect of that burglary – either:

- practised information – Later these facts should be very easily recalled, so misinformation should have little effect.
- unpractised information – Later these facts would often be temporarily forgotten, so misinformation was predicted to have a substantial effect.

The participants first studied information about both burglaries. A practice session followed where half the information about one of the burglaries was tested several times. All participants were then asked to recall as much as they could about both burglaries – this allowed the experimenters to see what was remembered and what was forgotten. Next the participants were asked a few more questions about the burglaries; one of the questions included one piece of misinformation (e.g. necklace was replaced with earrings). Finally they took a forced choice recognition test, in which the critical question required the person to choose between the original information, the misinformation and one other alternative.

Results and implications

In the free recall test that preceded the misinformation, retrieval-induced forgetting occurred: participants were best at remembering practised information and worst at remembering the unpractised information.

As Saunders and MacLeod predicted, people were more likely to be misled when the misinformation applied to the items they were least likely to remember – the forgotten information from the practised burglary. For unpractised (i.e. forgotten) information, 60% of the people were misled whereas only 16% were misled on practised information.

In real life, witnesses to crimes are often questioned more than once, so it is important to be aware that repeated questioning about some aspects of an event could leave them more susceptible to accidental misinformation about other, related aspects.

Saunders, J., & MacLeod, M.D., 2002, 'New evidence on the suggestibility of memory: The role of retrieval-induced forgetting in misinformation effects', *Journal of Experimental Psychology: Applied*, 8, 127–42.

The misinformation effect

The distortion of memory through the incorporation of new information has been an important research topic for psychologists concerned both with the practical implications for eyewitness testimony, and with theoretical accounts of the nature of memory.

Loftus and colleagues have explored in depth the *misinformation effect* (Fruzzetti et al., 1992; Loftus & Loftus, 1980). This arises when misleading information is introduced indirectly. For example, Loftus, Miller and Burns (1978) showed participants a series of slides along with the story of a road traffic accident. Later, the participants were questioned about the event. One of the questions was slightly different for half of the participants, in that it referred to a Stop sign instead of a Yield (Give Way) sign. Participants who were asked the question with the misleading information were more likely to identify falsely that particular slide in a later recognition memory test. These participants tended to choose the slide with the road sign that had been mentioned in the misleading question, rather than the one they had actually seen.

misinformation effect recall of misleading information presented after an eyewitness experience

Loftus and colleagues have repeatedly demonstrated similar distortions of memory reports after intervening, misleading questioning. The findings are robust and have implications for the sort of questions that eyewitnesses of crimes and accidents should be asked if their recall is to be as accurate as possible. However, the basis of the misinformation effect is disputed (see Chandler & Fisher, 1996, for a review). It is possible that the participants' original memories are permanently distorted by the questioning, but it is also possible that the questions supply information that the participants would not otherwise be able to remember (see Saunders & MacLeod, 2002).

False memories

Related to the misinformation effect, but with more potentially serious consequences, are recovered and false memories (Ceci & Bruck, 1995; Loftus & Ketcham, 1994). Under therapy, some adults have recovered memories of alleged abuse in childhood that have led to criminal convictions (Loftus & Ketcham, 1994).

But substantial research has shown that, under certain circumstances, false memories can also be created. Sometimes these are benign (Roediger & McDermott, 1995). However, it is also possible to create, using suggestions and misleading information, memories for 'events' that the individual believes very strongly happened in their past but which are, in fact, false (Ceci & Bruck, 1995; Loftus & Ketcham, 1994). So it remains at least plausible that some abusive events that people 'remember' are in fact false memories.

Learning strategies

What we remember depends, in part, on how we were thinking and acting at the time of the original experience. This knowledge can allow us to develop strategies that help us modify what we remember.

The role of rehearsal

An early strategy often adopted by children is to repeat material over and over again. The mere repetition of information, with no additional thought about meaning or associations, can help us to retain information for a few seconds, but it is a very poor method of learning for the longer term, as demonstrated by Craik and Watkins (1973). Their participants learned lists of words. In one condition, they were encouraged to repeat the last few words over and over again for some time before recall. These participants recalled the repeated words well in the immediate test, but at the end of the experiment all of the different lists that had been presented were tested. In the final test, the words that had been rehearsed repeatedly (and remembered better in the immediate test) were recalled no better than other words.

This rehearsal was described as *maintenance rehearsal* – maintaining the memory temporarily but doing nothing for longer-term memory.

maintenance rehearsal repeating items over and over, maintaining them in short-term memory but not increasing their long-term recall

In contrast to maintenance rehearsal is *elaborative rehearsal*. Rather than simply repeating information in an effort to maintain its availability, in elaborative rehearsal the meaning of the information is considered and elaborated. Although both types of rehearsal can keep information available for a short time, recall after a delay is much better when the information has been rehearsed elaboratively than when it has merely been rehearsed in a maintenance fashion (Bjork & Jongeward, 1975).

elaborative rehearsal considering the meaning of information

Expanding retrieval practice

Regardless of the type of rehearsal, later recall of information benefits from spaced retrieval practice – a technique for maximizing learning with the minimum of effort applied at the optimal moment. The underlying principle here is that memory is strengthened most when recall is attempted just before it becomes too difficult to accomplish (Bjork & Bjork, 1992).

When we first encounter some information, it may be relatively fragile in terms of memorability. By successfully recalling the information correctly a short while after studying it, we are more likely to recall it again later, so we can allow a somewhat longer delay before our next successful retrieval effort. With each successful effort, the delay can increase and still lead to further successes.

The effectiveness of this expanding schedule for retrieval practice was demonstrated by Landauer and Bjork (1978). They showed fictitious first and last names to their participants, who were then asked to recall the last names when the first names were shown again. The tests were scheduled to explore a range

Trial n+	1 2 3 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4
Short	P n T n T n T
Moderate	P n n n n T n n n n T n n n n T
Long	P n n n n n n n n n n T n n n n n n n n n n T n n n n n n n n n n T
Expanding	P n T n n n n T n n n n n n n n n n T

Figure 11.10

The testing conditions from Landauer & Bjork (1978). Short, moderate, long and expanding schedules are illustrated. The numbers across the top count the trials, starting at 1 for the initial presentation. *P* represents the presentation of a first and last name, *n* stands for an intervening trial with another name and *T* is a test of retrieval of the last name when the first name is presented.

of possibilities, including testing after short, moderate and long intervals filled with intervening items, and a further condition, the expanding schedule, in which the tests were at first introduced after a short delay and then the interval was steadily increased. For the expanding schedule, the first test took place immediately, the second test after three intervening items and the third after ten further items. The testing conditions are illustrated in figure 11.10. Landauer and Bjork found that any retrieval practice was beneficial (relative to the control unpractised condition), but that the greatest benefit was found for the expanding schedule, which produced recall at approximately twice the level of unpractised items.

Expanding retrieval practice is an excellent strategy for students. It is relatively undemanding in terms of the effort and creativity required, and can be applied to virtually any material (Morris & Fritz, 2002).

The benefits of spaced study

It is natural to plunge intensively into trying to learn new information, but this strategy has been shown repeatedly to be misguided (Dempster, 1996). The benefits of spacing study trials were observed by Ebbinghaus (1885/1964), who found that spreading his study sessions over three days approximately halved the amount of time actually spent in actively studying the lists. In fact, two spaced presentations of material to be learned are often twice as effective as two massed presentations (Dempster, 1996).

Bahrick and Phelps (1987) demonstrated the robustness of the spaced study effect. They compared the performance of participants who had originally learned and then relearned Spanish vocabulary by testing them eight years after the teaching session. One group had originally learned and relearned the vocabulary with an interval between learning and relearning of 30 days. Another group had learned and relearned on the same day. Eight years later, the participants who had learned and relearned with a 30-day interval performed at a level 250 per cent higher than the same-day learning/relearning group!

Mnemonics

Many students are familiar with rhymes such as '30 days hath September . . .', whose rhythm and rhymes provide structures that aid recall (Morris & Gruneberg, 1979) and with first-letter *mnemonics* such as 'Richard of York Gave Battle in Vain' that help recall order – in this case, the colours of the rainbow (Morris & Cook, 1978).

mnemonics techniques for improving memory

method of loci a mnemonic technique used to improve memory by creating images that link the items to be remembered with a series of familiar locations

But the oldest mnemonic method is the *method of loci*, traditionally attributed to Simonides around 500 BC and taught from Classical times until the present day. The technique involves knowing a series of places or loci that are familiar yet distinct – students might use places around their campus. The first item to be remembered is imaged in the first of these places, the second item in the second place, and so on. Recall then involves mentally revisiting the places and re-experiencing the images. Research has shown the technique to be highly effective (Morris, 1979), but its use is obviously limited by the availability of suitable loci and material to image.

The method of loci has since been elaborated into the more flexible pegword system, using the phonetic mnemonic in the construction of the pegwords (Higbee, 2001). Easily imagined pegwords that can be relatively easily learned replace the places of the method of loci. For example, we might learn words to represent each of the numbers from 1 to 100. The words are easily learned because they are constructed according to a few simple rules that underlie the phonetic mnemonic. Each digit is replaced by a specific consonant sound and then vowel sounds are inserted in between to create concrete, imageable words instead of number combinations (for which it is more difficult to create images). In the phonetic mnemonic the consonant sounds for the digits 1 and 2 are 't' and 'n', respectively. So, the number 21 can be represented by 'net' or 'nut'. The full phonetic mnemonic and pegwords for the numbers 1 to 100 can be found in Higbee (2001).

Pegword mnemonics allow a much more flexible use of the imagery mnemonic than the method of loci and can be dramatically effective (Bellezza, 1996; Morris & Reid, 1970); they form the basis of

pegword mnemonics method for remembering items by imagining them interacting with a learned set of peg items most professional memory improvement techniques. The pegs provide easily accessed memory cues, while the use of imagery links the cue and the item to be remembered through visuospatial interaction (Morris & Stevens, 1974).

Imagery mnemonics have been developed to tackle a range of practical memory problems. For example, Morris, Jones and Hampson (1978) evaluated an imagery mnemonic that was recommended by several stage memory performers. To remember a name, it had to be converted into some easy-to-image pegword form. For example, the name Gordon could be converted into a 'garden'. Then a garden would be imagined growing on some prominent feature of the person's face to link the pegword cue and the item to be remembered. By deciphering the pegword cue 'garden' into 'Gordon', this mnemonic produced an 80 per cent improvement in the learning of names.

Similar techniques have been extended to language learning, such as the *Linkword system* – extensively investigated and developed by Gruneberg (1987, 1992). The foreign words are converted to some similar-sounding English word that can be easily imaged. A mental image is then formed to link the image with the actual meaning of the foreign word. So, for example, the French for tablecloth is *nappe*, so Gruneberg recommends imagining having a nap on a tablecloth.

Wilding and Valentine (1997) describe studies of memory champions and other memory experts, many of whom have discovered for themselves the value of mental imagery as a memory improvement technique. The use of imagery is not essential for memory improvement, of course. It is just one way in which material that is superficially meaningless and disconnected can be made more meaningful and connected and therefore easier to remember. A simple way of connecting words from a list is to compose a story. Bower and Clark (1969) showed that getting people to make up a story that linked together a list of 12 words made later recall of the words very much better.

Reflecting on our own learning

Metamemory refers to the understanding that people have of their own memory.

metamemory someone's understanding about how their memory works

When attempting to learn something, it seems reasonable to assume that we will monitor our own learning and schedule subsequent study activities to attempt to improve it. But how accurate are we at judging how well we have learned something? If the judgement is made soon after studying the material, we are comparatively poor at predicting our later performance. On the other hand, when the judgement is made after a delay, we are relatively better at making this judgement (Dunlosky & Nelson, 1992). If we can adequately judge how well (or poorly) we have learned material, we can apply this knowledge to inform our subsequent study plans, spending additional time on material that is less well learned.

Laboratory studies suggest that people schedule their time appropriately, in just this way. But preliminary work by Metcalfe and Son (1999) suggests that, in some more natural learning situations, people are more likely to schedule their study time with emphasis on areas that they know well or find particularly interesting, neglecting areas that need work.

FINAL THOUGHTS

Memory plays a critical role in many aspects of our daily existence. Indeed, without memory many of the other capacities that we consider in this book (such as language, the identification of familiar objects or the maintenance of social relationships) would not be possible.

It should be apparent after reading this chapter that memory represents a collection of abilities rather than a unitary capacity (as might be implied by an unfortunate tendency to refer to our memory in the singular in everyday speech). Moreover, memory is not a passive receptacle, nor is it necessarily a truthful recording of events in our lives. It is an active and selective process, reflecting both strengths and weaknesses, which often represent the opposite sides of the same coin.

In a recent book, Dan Schacter (2001) refers to the 'seven sins of memory', highlighting the kinds of errors to which human memory is prone. At the same time, our memory tends to record events in our lives associated with situations of (potential or actual) threat or reward quite effectively – something that was probably very important for survival in our evolutionary past.

Summary

- Memory is important to people; it plays a role in comprehension, learning, social relationships, and in many other aspects of life.
- Memory for a past event or information is indicated whenever a past event or information influences someone's thoughts, feelings, or behaviour at some later time.
- The person need not be aware of any memory for the past event, and might not even have been aware of the event when it occurred; the intention to remember is also unnecessary.
- Memory is observed through free recall, cued recall, recognition, familiarity, and other behavioural changes such as priming.
- Memory seems to involve more than just one system or type of process, as there is evidence that different sorts of memories can be influenced differently by specific manipulations or variables.
- Memory, like many topics in psychology, is difficult to study, in that it must be inferred from observable behaviour.
- Memory is not a veridical copy of a past event – events are constructed by people as they occur; remembering involves the re-construction of the event or information.
- Memory is the result of an interaction between the world and the person.
- In the past, when the event occurred, the personal experience of that event was constructed; at a later time, the event that is remembered is a new construction based partly upon that earlier construction.
- Psychologists have improved our understanding of many variables that influence memory, but there is still much to learn. Nevertheless, we can each be wiser users of our own memories by using effective mnemonic strategies and directing our efforts appropriately to help us learn and remember information.

REVISION QUESTIONS

1. Is memory dependent upon the intention to learn or recall? (Think of examples from your own life where you remembered something that you never intended to learn. Think of examples where you remember something without any intention to remember it.)
2. What is the difficulty in inferring memory from behaviour? How do psychologists deal with the problem?
3. Why is it not appropriate to think about different types of memory as existing along a continuum?
4. What evidence is there that memory is not like a tape recording?
5. We are aware of some memories, and unaware of others – awareness could be a useful way of distinguishing between different types of memory. What evidence supports this distinction?
6. Are there advantages of considering memory processes within an information processing framework? How might this approach lead to conceptual mistakes and misunderstandings?
7. Which approach is likely to produce better memory: copying information or explaining information?
8. How is memory performance dependent upon the interrelationship between the previous event and the later event?
9. What part does meaning play in influencing what we can remember?
10. Why do we sometimes remember things that did not happen?
11. Are there special techniques that can improve memory? If so, how do they work?

Further Reading

Baddeley, A.D. (1997). *Human Memory: Theory and Practice*. Revised edn. Hove: Psychology Press.
Review of research on memory, with particular emphasis upon Baddeley's personal interests including working memory, written at a slightly higher level than *Essentials of Human Memory* (see next entry).

Baddeley, A.D. (1999). *Essentials of Human Memory*. Hove: Psychology Press.
An interesting and readable introduction to memory written by one of the leading experts on memory.

Cohen, G. (1996). *Memory in the Real World*. 2nd edn. Hove: Psychology Press.
Another comprehensive and readable review of memory research with particular emphasis on memory outside the laboratory.

Gruneberg, M., & Morris, P.E. (eds) (1992). *Aspects of Memory. Vol. 1*. 2nd edn. London: Routledge.
A more applied perspective with particularly clear explanations.

Haberlandt, K. (1999). *Human Memory: Exploration and Application*. Boston: Allyn and Bacon.
An excellent review of memory research with particular emphasis on currently popular topics.

Higbee, K.L. (2001). *Your Memory: How it Works and How to Improve it*. New York: Marlowe.
An easy-to-read review of methods of improving memory that is written for a general audience but which is based upon psychological research that is fully documented through footnotes.

Morris, P.E., & Gruneberg, M. (eds) (1992). *Theoretical Aspects of Memory*. 2nd edn. London: Routledge.
Very accessible coverage of many major areas in memory research, written for beginning students in psychology.

Parkin, A. (1997). *Memory and Amnesia: An Introduction*. 2nd edn. Oxford: Blackwell.
An introduction to memory research, with particular emphasis on memory disorders and the physiological damage that typically underlies them.

Animal list for p. 228

Cat, dog, horse, mouse, sheep, cow, goat, rat, lion, tiger, bear, donkey, elephant, monkey, whale.

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